Appendix I

Ecological Resources

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Ecological Resources

Appendix I provides additional information regarding potential impacts to terrestrial and aquatic ecological resources that may result from implementation of Alternative Groups A, B, C, D_1, D_2, D_3, E_1, E_2, and E_3, or the No Action Alternative. Potential impacts to terrestrial resources would occur in the near term, i.e., during waste management operations and under current conditions. These relate primarily to surface disturbance associated with disposal in the Low Level Burial Grounds (LLBGs), the Environmental Restoration and Disposal Facility (ERDF), and in the proposed disposal facility near the PUREX Plant; Area C from which capping materials would be obtained and the associated stockpile area and conveyance road; and construction sites for the additional Central Waste Complex (CWC) facilities and New Waste Processing Facility. Potential impacts to Columbia River riparian and aquatic resources could occur in the long term, i.e., up to 10,000 years following the conclusion of waste management operations. These relate primarily to the eventual migration of radionuclides and other hazardous chemicals through the vadose zone to groundwater and on to the Columbia River.

I.1 Background

The 24 Command Fire, a range fire that occurred in late June–early July 2000 (DOE-RL 2000), burned 163,884 acres on the central part of the Hanford Site and the Fitzner/Eberhardt Arid Lands Ecology (ALE) Reserve (Baker 2000). The 24 Command Fire covered the 200 West Expansion Area, some of which has been identified for construction of the additional CWC facilities and the New Waste Processing Facility; a large area west and south of that location, including Area C; and the southern portion of the corridor between the 200 West Area and 200 East Area, including the ERDF. The 24 Command Fire did not affect the LLBGs in the 200 West Area (although some of these border the 200 West Expansion Area), nor did it reach the 200 East Area.

In general, approximately 85 percent of the burned area experienced severe fire intensity, resulting in complete destruction of all vegetation and organic litter on the soil surface (Baker 2000). In moderately burned areas, there was partial removal of the shrub layer and understory. Many of the severely and moderately burned areas have since been colonized by alien annual weeds, such as Russian thistle (*Salsola kali*) and cheatgrass (*Bromus tectorum*).

The most severely burned areas, particularly west and southwest of the 200 West Area (including the area identified for construction of the additional CWC facilities and the New Waste Processing Facility), were, and continue to be severely eroded by wind (Becker and Sackschewsky 2001a, 2001b; Sackschewsky and Becker 2001). Much of the topsoil and likely much of the buried seed (Baker 2000) have been removed. Plant communities in these areas, particularly the shrub components, may not recover before project-related surface disturbance because of a lack of buried seed (Baker 2000), relatively long distances to upwind seed sources, continued wind erosion, and competition by weedy species.

In contrast, some of the pre-fire shrub and understory vegetation in the moderately burned areas (including most of Area C and the ERDF) was not removed or is recovering, and these areas have not been affected as severely by wind erosion. These plant communities thus have likely retained more of their buried seed than those that were severely burned; this seed may germinate when conditions are suitable. Consequently, some of these communities are expected to partially or fully recover before project-related disturbance, notwithstanding competition by weedy species.

I.2 Impacts to Terrestrial Resources Resulting from Surface Disturbance

I.2.1 Alternative Group A

LLBGs in the 200 East Area – Impacts to Habitats and Plant Species of Concern. The LLBGs in the 200 East Area are surveyed annually, consistent with the DOE *Ecological Compliance Assessment Management Plan* (ECAMP) (DOE-RL 1995a). The 218-E-10 and 218-E-12B LLBGs have been cleared of most of their original vegetation, greatly increasing their susceptibility to noxious weed invasion.

Noxious weeds on the Hanford Site are managed under the Integrated Pest Management (IPM) program (WHC 1995), and the primary means of control is herbicides. IPM personnel are required to obtain training, licenses, and certifications (WHC 1995) in order to ensure compliance with Washington State Department of Agriculture rules relating to the use of restricted herbicides in ground and aerial applications. Compliance with these rules facilitates effective control of target populations with minimal accidental overspray of and herbicide drift into non-target areas. Herbicide drift is minimized primarily by deploying herbicides under optimal weather conditions (Renne and Wolf 1976) and using drift retardants. Drift retardants increase droplet size, increasing settling rate and thus rendering herbicides less susceptible to drift.

Cheatgrass and Sandberg's bluegrass (*Poa sandbergii*), a native perennial, dominate approximately two-thirds of the 218-E-10 and 218-E-12B LLBGs. Crested wheatgrass (*Agropyron cristatum*), a non-native perennial planted for a variety of purposes including dust suppression and reduction of water infiltration into the vadose zone, dominates the other third (Brandt 1998, 1999; Sackschewsky 2000, 2001, 2002a). The 218-E-10 and 218-E-12B LLBGs receive regular herbicide applications and thus have essentially no habitat value for native broad-leaved species such as big sagebrush (*Artemisia tridentata*). Consequently, continued use of these LLBGs, or new disturbance of the extant plant communities within them, would not result in the loss of any habitats designated by Washington State as priority habitats (DOE-RL 2003). However, native habitats could develop if herbicide spraying ceases.

Two plant species of concern have been observed within the 218-E-10 and 218-E-12B LLBGs. The most notable is Piper's daisy (*Erigeron piperianus*). The State of Washington Natural Heritage Program

(WHNP) lists Piper's daisy as sensitive (a taxon that is vulnerable or declining and could become endangered or threatened in Washington without active management or removal of threats [WNHP 2002]) (Sackschewsky and Downs 2001). Sensitive species are considered Level III resources (Table I.1) under the *Hanford Site Biological Resources Management Plan* (BRMaP) (DOE-RL 2001). This species was observed within the 218-E-12B and 218-E-10 LLBGs during spring 1999 (Brandt 1999) but not in spring 2000, 2001, or 2002 (Sackschewsky 2000, 2001, 2002a). Piper's daisy populations on these two LLBGs have been reduced or eliminated, likely as a result of regular herbicide applications. However, these populations could regenerate from buried seed, particularly if herbicide spraying ceases.

Table I.1. Hanford Site Biological Resources Management Plan Resource Levels and Their Definitions

Resource Level	Definition
I	Those resources that—because of their recreational, commercial, or ecological role or previous protection status—require at a minimum some level of status monitoring. Mitigation is not normally required.
II	Those resources that—to show compliance with procedural and substantive laws such as NEPA, CERCLA, and the Migratory Bird Treaty Act—require consideration of potential adverse impacts. Mitigation is most often accomplished by avoidance and impact minimization, except in the case of recovering shrub-steppe habitat,[a] for which mitigation via rectification or compensation is recommended.
III	Those resources that—because of their state listing, potential for federal or state listing, unique or significant value for plant, fish, or wildlife species, special administrative designation, or environmental sensitivity—require mitigation. When avoidance and minimization are not possible or are insufficient, mitigation via rectification or compensation is recommended.
IV	Those resources that—because of their federally protected legal status or their regional and national significance—justify preservation and the primary management option. Typically, these cannot be mitigated unless it is by compensation via acquisition and protection of in-kind resources.

(a) Habitat characterized by short-statured, widely spaced, small-leaved shrubs, sometimes aromatic (of, related to, or containing the six-carbon ring typical of the benzene series and related organic groups), with brittle stems and an understory dominated by perennial bunchgrasses.

The other plant species of concern observed within the 218-E-10 and 218-E-12B LLBGs is crouching milkvetch (*Astragalus succumbens*), a Washington State Watch List species (plant taxon that is of concern but is considered to be more abundant and/or less threatened in Washington than previously assumed [WNHP 2002]) (Sackschewsky and Downs 2001). Watch List species are considered Level I resources (Table I.1) under BRMaP (DOE-RL 2001). This species was observed in spring 2000, 2001, and 2002 within Trench 94 in the 218-E-12B LLBG and on the northeast side of the 218-E-10 LLBG (Sackschewsky 2000, 2001, 2002a). Crouching milkvetch is relatively common on the Central Plateau (Sackschewsky and Downs 2001). Therefore, disturbance of those individuals on the 218-E-12B and 218-E-10 LLBGs would not be likely to adversely affect the overall local population.

LLBGs in the 200 West Area – Impacts to Habitats and Plant Species of Concern. The LLBGs in the 200 West Area are surveyed annually consistent with ECAMP (DOE-RL 1995a). The 218-W-3A, 218-W-3AE, 218-W-4B, and 218-W-5 LLBGs in the 200 West Area are sparsely colonized by cheatgrass, Russian thistle, and crested wheatgrass (Brandt 1998, 1999; Sackschewsky 2000, 2001, 2002a). These receive regular herbicide applications and thus have essentially no habitat value for native species. Consequently, continued use of these LLBGs, or new disturbance of the extant plant communities within them, would not result in the loss of any habitats designated by Washington State as priority habitat (DOE-RL 2003). However, native habitats could develop if herbicide spraying ceases.

Most of the developed portion of the 218-W-4C LLBG, bounded on the west by Dayton Avenue and on the north and south by 19th and 16th streets, respectively, is highly disturbed and has a sparse cover of cheatgrass. However, some portions of this LLBG now have relatively thick stands of Indian ricegrass (*Oryzopsis hymenoides*) and needle-and-thread grass (*Stipa comata*) (Brandt 1998, 1999; Sackschewsky 2000, 2001, 2002a), both native perennial species. This developed portion of the 218-W-4C LLBG receives regular herbicide applications and thus has essentially no habitat value for native species. Consequently, continued use of the developed portion of the 218-W-4C LLBG, or new disturbance of the extant plant communities within it, would not result in the loss of any habitats designated by Washington State as priority habitat (DOE-RL 2003). However, native habitats could develop if herbicide spraying ceases.

The undeveloped southeastern portion of the 218-W-4C LLBG, along 16th Street, is dominated by mature sagebrush, with gray and green rabbitbrush (*Chrysothmnus nauseosus*) as minor overstory components. The understory consists primarily of needle-and-thread grass, cheatgrass, and crested wheatgrass. Development of the southeastern portion of the 218-W-4C LLBG would result in the loss of sagebrush steppe (shrub-steppe dominated by sagebrush), considered a priority habitat by the State of Washington (DOE-RL 2003) and a Level III resource under BRMaP (DOE-RL 2001).

One plant species of concern has been observed within some of the 200 West LLBGs—stalked-pod milkvetch (*Astragalus sclerocarpus*), a Washington State Watch List species (Sackschewsky and Downs 2001) and thus a Level I resource (DOE-RL 2001). Stalked-pod milkvetch was observed in spring 1998, 1999, 2000, 2001, and 2002 at the extreme western edge of the 218-W-5 LLBG and within the undeveloped portion of the 218-W-4C LLBG (Brandt 1998, 1999; Sackschewsky 2000, 2001, 2002a). Stalked-pod milkvetch is relatively common on the Central Plateau (Sackschewsky and Downs 2001). Therefore, disturbance of those individuals on the 218-W-5 and 218-W-4C LLBGs would not likely adversely affect the overall local population.

LLBGs in the 200 East and 200 West Areas – Impacts to Wildlife and Wildlife Species of Concern. Wildlife that could be impacted by disturbance of the 200 East and 200 West LLBGs includes the mule deer (*Odocoileus hemionus*), Great Basin pocket mouse (*Perognathus parvus*), side-blotched lizard (*Uta stansburiana*), and several migratory bird species. Ground-nesting birds that have been observed, and that may nest within the 200 East and 200 West LLBGs, include the horned lark (*Eremophila alpestris*), killdeer (*Charadrius vociferous*), long-billed curlew (*Numenius americanus*), and Western meadowlark (*Sturnella neglecta*) (Sackschewsky 2001). Ground disturbance during the nesting season, generally March through July, could destroy eggs and young and temporarily displace nesting individuals into other areas of the Hanford Site. The nests, eggs, and young of migratory birds are protected under the Migratory Bird Treaty Act (MBTA) (16 USC 703-712, as amended). Protection is generally accomplished by conducting ground-disturbing activities outside the nesting season, generally August through February.

Proposed Disposal Facility Near the PUREX Plant in 200 East Area – Impacts to Habitats and Plant Species of Concern. The proposed disposal facility near the PUREX Plant is surveyed annually consistent with ECAMP (DOE-RL 1995a). Unlike the majority of the LLBGs, the original vegetation in the proposed disposal facility near the PUREX Plant has not been cleared. The overstory is dominated by sagebrush (25% cover), with green rabbitbrush (*Chrysothmnus viscidiflorus*) as a minor component. The understory is dominated by cheatgrass and Sandberg's bluegrass. Development of the proposed disposal facility near the PUREX Plant would result in the loss of sagebrush steppe, considered a priority habitat by the State of Washington (DOE-RL 2003) and a Level III resource under BRMaP (DOE-RL 2001). No plant species of concern were observed in the proposed disposal facility near the PUREX Plant during the annual field survey of summer 2002.

Proposed Disposal Facility Near the PUREX Plant in 200 East Area – Impacts to Wildlife and Wildlife Species of Concern. Wildlife that could be affected by disturbance of the proposed disposal facility near the PUREX Plant includes the black-tailed jackrabbit (*Lepus californicus*), mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), Northern pocket gopher (*Thomomys talpoides*), and several migratory bird species. Shrub- and ground-nesting birds that have been observed and that likely nest within the proposed disposal facility near the PUREX Plant include the sage sparrow (*Amphispiza belli*) and Western meadowlark (*Sturnella neglecta*), respectively. Ground disturbance during the nesting season, generally March through July, could destroy eggs and young and temporarily displace nesting individuals into other areas of the Hanford Site. The nests, eggs, and young of migratory birds are protected under the MBTA. Protection is generally accomplished by conducting ground-disturbing activities outside the nesting season, generally August through February.

Two wildlife species of concern were observed within the proposed disposal facility near the PUREX Plant—the black-tailed jackrabbit and sage sparrow, both Washington State candidate species (species that the Washington Department of Fish and Wildlife will review for possible listing as endangered, threatened, or sensitive [WDFW 2002]). The distribution of the black-tailed jackrabbit (BMNHC 2002) and sage sparrow within Washington is limited mostly to the Columbia Basin. Both species have a strong affinity for sagebrush habitat. Removal of sagebrush within the proposed disposal facility near the PUREX Plant would likely have a minimal impact on populations of these species within the Columbia Basin.

Area C – Impacts to Habitats. Much of the original vegetation in Area C was burned in the 24 Command Fire. Pre-fire plant communities and land cover types in Area C consisted of the following:

- needle-and-thread grass/Indian ricegrass
- big sagebrush/needle-and-thread grass
- bluebunch wheatgrass (*Agropyron spicatum*)/Sandberg's bluegrass
- rabbitbrush (*Chrysothamnus* spp.)/bunchgrass mosaic
- Sandberg's bluegrass/cheatgrass

- big sagebrush/Sandberg's bluegrass/cheatgrass
- abandoned old agricultural fields
- disturbed (inactive borrow pit) (Figure I.1).

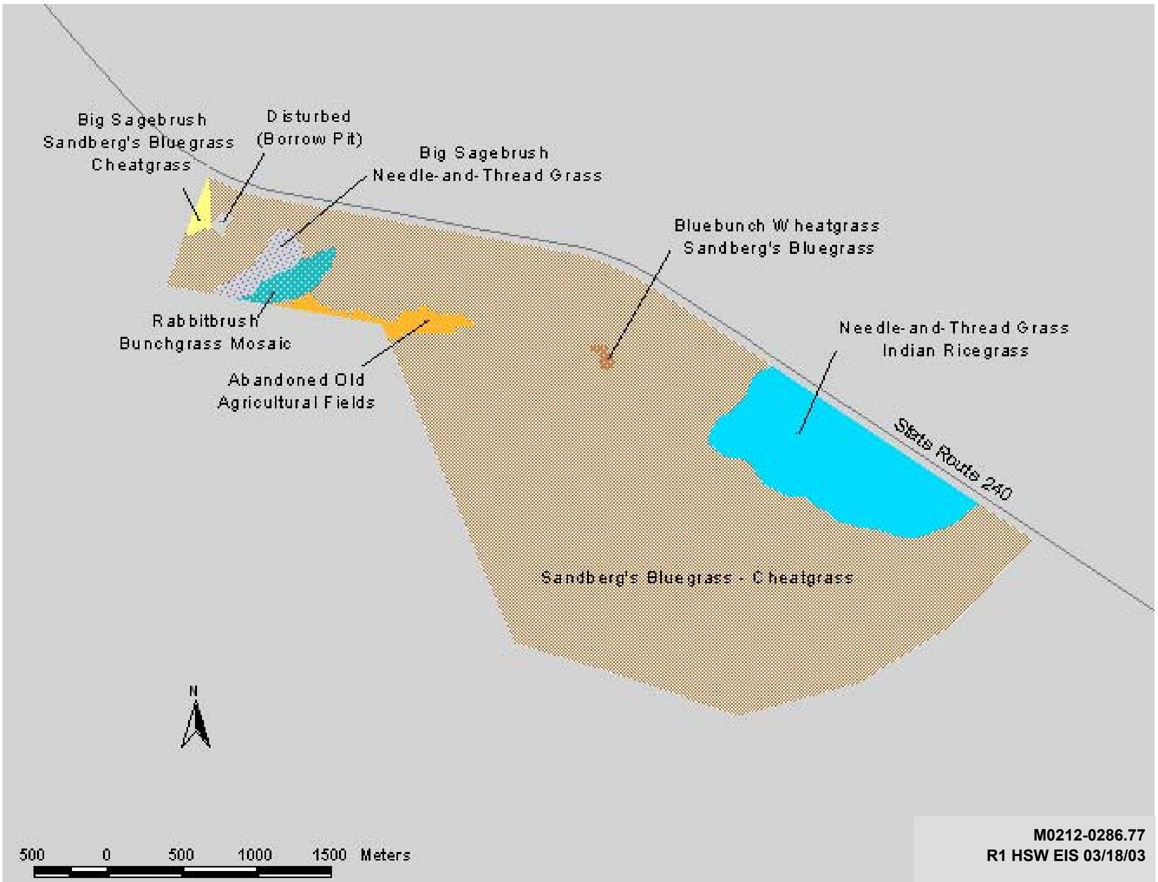

Figure I.1. Plant Communities in Area C Before the 24 Command Fire of June 2000 (Data collected 1994 and 1997 by TNC; 1991 and 1999 by Pacific Northwest National Laboratory [PNNL]. Map created January 2002 by PNNL).

Needle-and-Thread Grass/Indian Ricegrass. The pre-fire needle-and-thread grass/Indian ricegrass community was designated a potential bitterbrush (*Purshia tridentata*)/Indian ricegrass sand dune complex community (Figure I.2) by The Nature Conservancy (TNC) of Washington. A potential plant community is one that, with the passage of time, is projected to dominate an undisturbed site, based on climate and other abiotic factors (Soll and Soper 1996). Thus, development of the potential bitterbrush/ Indian ricegrass community is based on long-term colonization by bitterbrush and eventual domination of the understory by Indian ricegrass.

The pre-fire needle-and-thread grass/Indian ricegrass community was designated an element occurrence of the bitterbrush/Indian ricegrass sand dune complex community type (Figure I.3). An element occurrence of a community type is one that meets the minimum standards set by the WNHP for

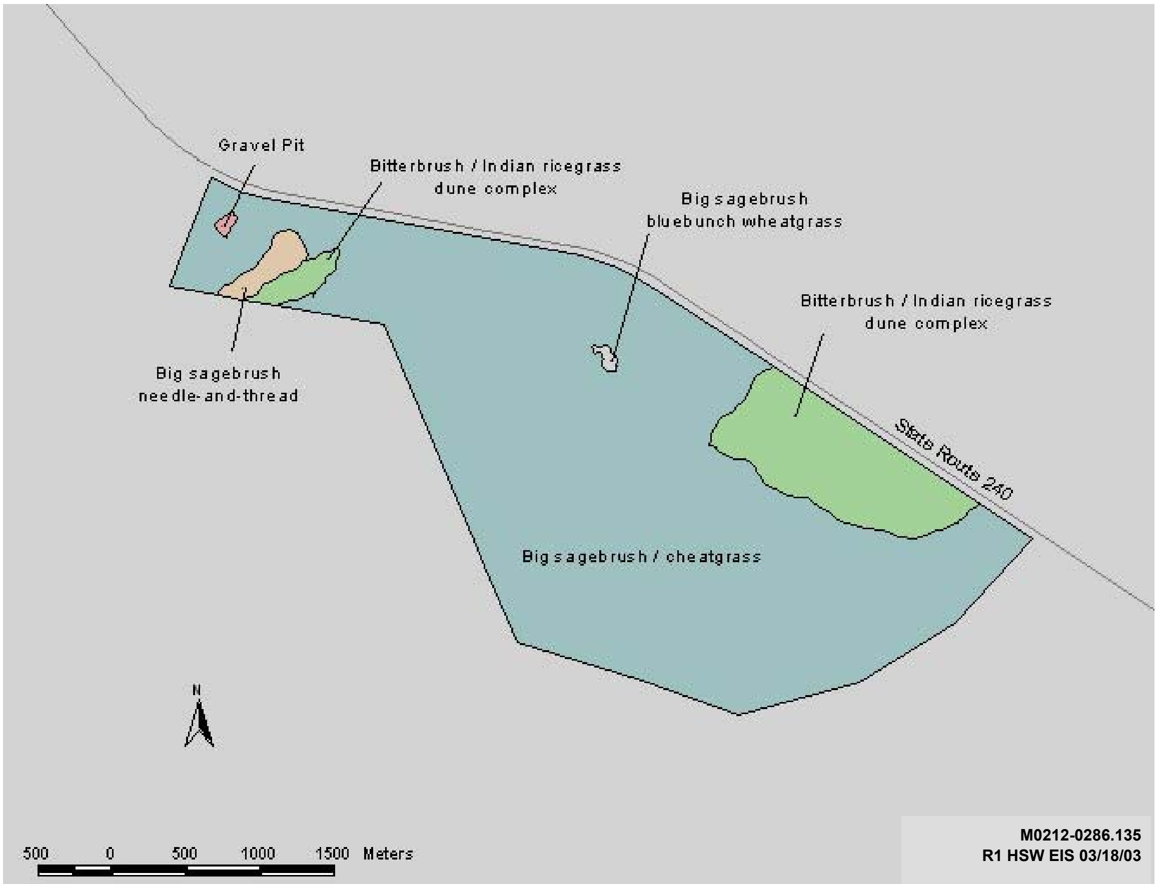

Figure I.2. Potential Plant Communities in Area C (Data collected 1994 and 1997 by TNC; 1991 and 1999 by PNNL. Map created January 2002 by PNNL).

ecological condition, size, and the surrounding landscape. Element occurrences are generally considered to be of significant conservation value from a state and/or regional perspective. More specifically, element occurrences on the Hanford Site may be considered integral to the preservation and sustenance of biodiversity in the Columbia Basin shrub-steppe. Element occurrences are tracked by the WNHP.

Element occurrences are designated Level IV resources (Table I.1) in BRMaP (DOE-RL 2001), the highest level of resource designation at the Hanford Site. Element occurrences, because of their regional significance, justify preservation as the primary management option, and impacts to these should be avoided where possible (DOE-RL 2001).

The dominant plant species in this community, as determined by ocular estimation of percentage ground cover, currently are cheatgrass (50 percent), needle-and-thread grass (15 percent), and Indian ricegrass (10 percent) (Attachment A to this appendix; Sackschewsky 2002d). This needle-and-thread grass/Indian ricegrass community should thus be re-designated cheatgrass/needle-and-thread grass/Indian

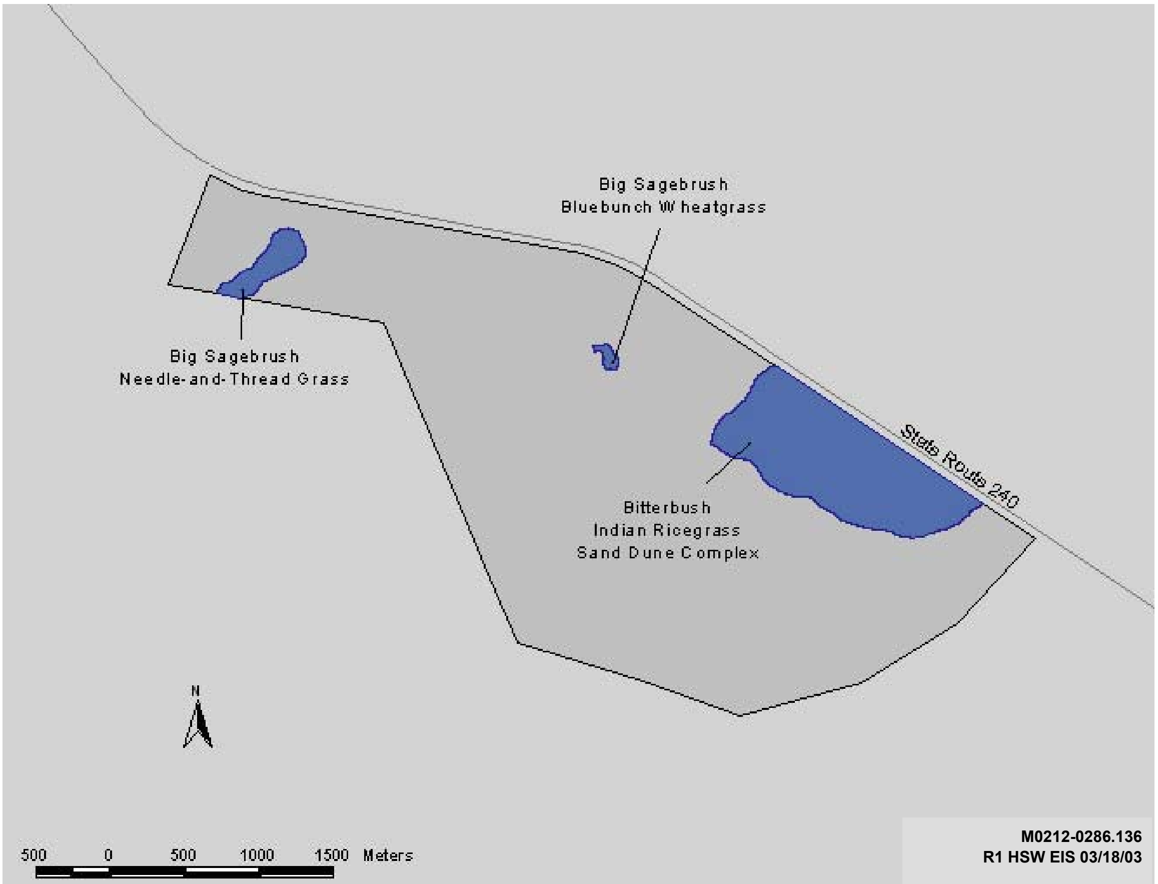

Figure I.3. Element Occurrences of Plant Community Types in Area C (Data collected 1994, 1995, and 1997 by TNC; 1996 by WNHP. Map created January 2002 by PNNL).

ricegrass (Figure I.4). Because bitterbrush is not currently present in this community (Attachment A to this appendix; Sackschewsky 2002d), it appears unlikely that it will become a bitterbrush/Indian ricegrass community prior to the start of new construction.

Big Sagebrush/Needle-and-Thread Grass. No potential (more advanced) community type has been designated by TNC for this pre-fire big sagebrush/needle-and-thread grass community (Figure I.2) (Soll and Soper 1996). This pre-fire community was designated an element occurrence (Figure I.3) (Soll and Soper 1996). However, big sagebrush appears to have been absent in the pre-fire community, based on observations made in the field in February and June 2002 (Sackschewsky 2002c, 2002d; Attachment A to this appendix), during which no burned shrub stumps and virtually no other burned shrub residue (e.g., branches) were observed. Therefore, its designation as an element occurrence may have been erroneous. However, this determination can be made only by the WNHP.

This community is currently much smaller than that defined by TNC (compare Figures I.1, I.2, and I.3 with I.4). The dominant plant species in this community currently are needle-and-thread grass (20 percent) and cheatgrass (20 percent) (Attachment A to this appendix; Sackschewsky 2002d). This big

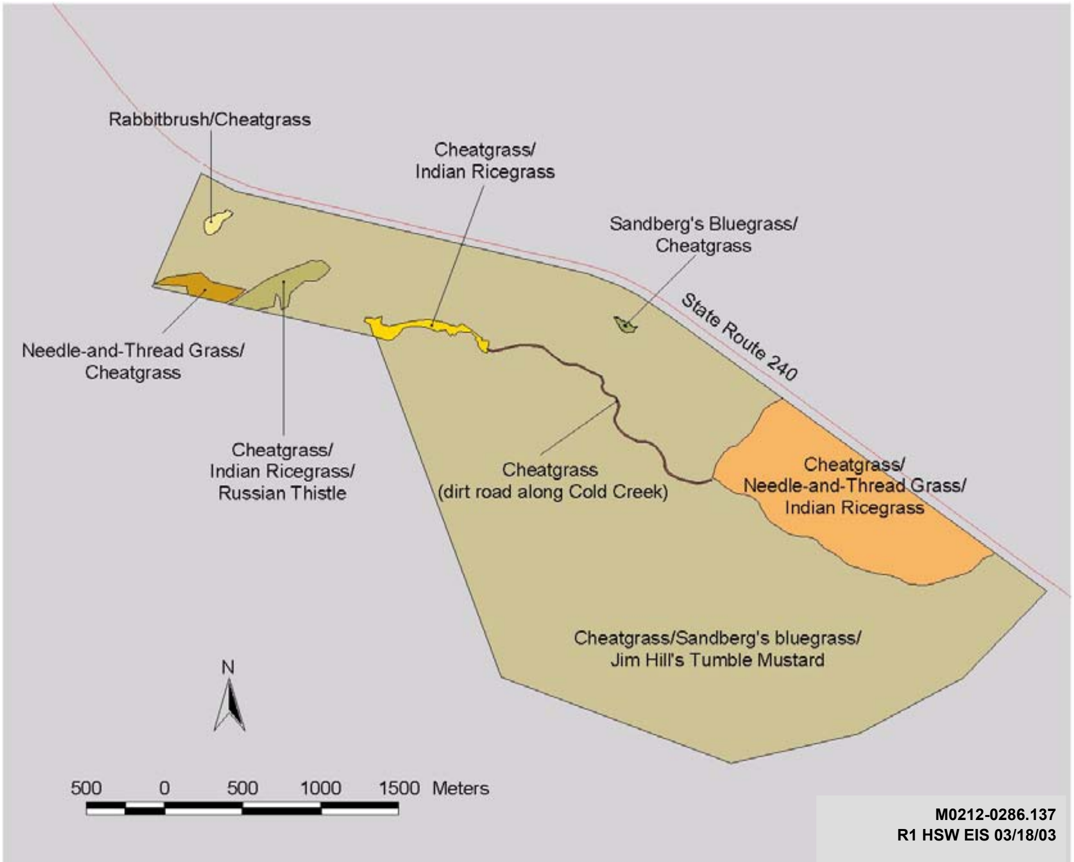

Figure I.4. Plant Communities in Area C After the 24 Command Fire of June 2000 (Data collected June and July 2002 by PNNL. Map created October 2002 by PNNL).

sagebrush/ needle-and-thread grass community should thus be re-designated needle-and-thread grass/cheatgrass (Figure I.4). Because sagebrush is not currently present in this community (Attachment A to this appendix; Sackschewsky 2002d), it appears unlikely that it could become a big sagebrush/needle-and-thread grass community prior to the start of new construction.

Bluebunch Wheatgrass/Sandberg's Bluegrass. The pre-fire bluebunch wheatgrass/Sandberg's bluegrass community, designated a potential big sagebrush/bluebunch wheatgrass community (Figure I.2) by Soll and Soper (1996), was designated an element occurrence of the big sagebrush/bluebunch wheatgrass community (Figure I.3) (Soll and Soper 1996).

The dominant plant species in this community currently are Sandberg's bluegrass (40 percent) and cheatgrass (10 percent). Bluebunch wheatgrass is a minor component of this community, i.e., much less than 1 percent cover (Attachment A to this appendix; Sackschewsky 2002d). This bluebunch wheatgrass/ Sandberg's bluegrass community should thus be re-designated Sandberg's bluegrass/cheatgrass (Figure I.4). The designation of this community as an element occurrence may be erroneous due to the insignificant amount of bluebunch wheatgrass. However, this determination can be made only by the WNHP. Because sagebrush is not currently present in this community (Attachment A to this appendix;

Sackschewsky 2002d), it appears unlikely that it could become a big sagebrush/bluebunch wheatgrass community prior to the start of new construction.

Rabbitbrush/Bunchgrass Mosaic. This pre-fire rabbitbrush/bunchgrass mosaic community has been designated a potential bitterbrush/Indian ricegrass sand dune complex community (Figure I.2) by Soll and Soper (1996).

The dominant plant species in this community currently are cheatgrass (20 percent), Indian ricegrass (10 percent), and Russian thistle (10 percent). Scattered burned and living rabbitbrush were a minor component of this community, i.e., much less than 1 percent cover (Attachment A to this appendix; Sackschewsky 2002d). This community should thus be re-designated cheatgrass/Indian ricegrass/Russian thistle (Figure I.4). Because living rabbitbrush are currently present (Attachment A to this appendix; Sackschewsky 2002d), and given the substantial Indian ricegrass component, this community will likely recover to its pre-fire condition (i.e., rabbitbrush/bunchgrass mosaic community) before the start of new construction.

Sandberg's Bluegrass/Cheatgrass. This area was designated a potential big sagebrush/cheatgrass community (Figure I.2) by Soll and Soper (1996). The dominant plant species in this community, except for the dirt road along Cold Creek, currently are cheatgrass (55 percent), Sandberg's bluegrass (15 percent), and Jim Hill's tumble mustard (*Sisymbrium altissimum*) (10 percent) (Attachment A to this appendix; Sackschewsky 2002d), an alien, annual weed. This community should thus be re-designated cheatgrass/ Sandberg's bluegrass/Jim Hill's tumble mustard (Figure I.4). The dominant plant species along the dirt road along Cold Creek is cheatgrass (50 percent) (Attachment A to this appendix; Sackschewsky 2002d), and should be considered a separate community (Figure I.4).

Widely scattered mature big sagebrush (<1 percent cover in the area of its occurrence [Attachment A to this appendix; Sackschewsky 2002d]), of which approximately 10 percent were alive, were observed in the southeastern portion of this cheatgrass/Sandberg's bluegrass/Jim Hill's tumble mustard community, within approximately 200 m (656 ft) of the border of Area C. This portion of the cheatgrass/Sandberg's bluegrass/Jim Hill's tumble mustard community is thus a Level II resource (Table I.1) under BRMaP (DOE-RL 2001). Seeding from remnant mature sagebrush may enable this portion of the community to become big sagebrush/cheatgrass before the start of new construction. However, because living, mature sagebrush are currently scarce and very limited in distribution, and given the relatively long upwind distance to external seed sources, the potential for sagebrush colonization of the remainder of this community before the start of new construction is expected to be low.

Big Sagebrush/Sandberg's Bluegrass/Cheatgrass. This area was designated a potential big sagebrush/cheatgrass community (Figure I.2) by Soll and Soper (1996). The dominant plant species in this community currently are cheatgrass (55 percent), Sandberg's bluegrass (15 percent), and Jim Hill's tumble mustard (*Sisymbrium altissimum*) (Attachment A to this appendix; Sackschewsky 2002d). This community should thus be re-designated cheatgrass/Sandberg's bluegrass/Jim Hill's tumble mustard (Figure I.4). No evidence was found to indicate that sagebrush had been a component of the pre-fire community, and sagebrush is not currently present in this area (Attachment A to this appendix; Sackschewsky 2002d). Thus, it appears unlikely that this area could become a big sagebrush/cheatgrass community prior to the start of new construction.

Abandoned Old Agricultural Fields. This area was designated a potential big sagebrush/cheatgrass community (Figure I.2) by Soll and Soper (1996). The dominant plant species in this community currently are cheatgrass (20 percent) and Indian ricegrass (10 percent) (Attachment A to this appendix; Sackschewsky 2002d). This community should thus be designated cheatgrass/Indian ricegrass (Figure I.4) because the current designation provides no information on species composition. Because sagebrush is not currently present in this area (Sackschewsky 2002d), it appears unlikely that this area could become a big sagebrush/cheatgrass community prior to the start of new construction.

Disturbed (Inactive Borrow Pit). Based on observations made in the field in February and June 2002 (Sackschewsky 2002c, 2002d), the inactive borrow pit was virtually unaffected by the 24 Command Fire, although vegetation all around it was removed. The dominant plant species in this community currently are gray rabbitbrush (5 percent) and cheatgrass (30 percent). Sagebrush is a minor component, at 1 percent cover (Attachment A to this appendix; Sackschewsky 2002d). This community should thus be designated gray rabbitbrush/cheatgrass (Figure I.4) because the current designation provides no information on species composition. Because the overstory is dominated by rabbitbrush and sagebrush is sub-dominant, this community should be considered a Level II resource under BRMaP (DOE-RL 2001).

Area C – Impacts to Wildlife. Wildlife that could be affected by disturbance of Area C include mammals—the badger (*Taxidea taxus*), coyote, elk (*Cervus elaphus*), mule deer, and Northern pocket gopher; birds—the horned lark, lark sparrow (*Chondestes grammacus*), rock wren (*Salpinctes obsoletus*), short-eared owl (*Asio flammeus*), and Western meadowlark; and reptiles—the side-blotched lizard (Attachment A to this appendix; Sackschewsky 2002d).

Of these avian species, those that are ground-nesting and that may nest within Area C include the horned lark and Western meadowlark. Ground disturbance during the nesting season, generally March through July, could destroy eggs and young and temporarily displace nesting individuals into other areas of the Hanford Site. The same temporal restrictions as set forth above in **LLBGs in the 200 East and 200 West Areas – Impacts to Wildlife and Wildlife Species of Concern** (page I.4) apply for conducting ground-disturbing activities outside the nesting season to protect the nests, eggs, and young of these species in this area.

An elk herd of approximately 660 animals uses the ALE Reserve and surrounding private lands (Tiller et al. 2000). After the 24 Command Fire, little vegetation was available on the ALE Reserve. Core use areas during the calving (March–June) and post-calving (July–August) periods in 2000 generally centered along the southern border of the ALE Reserve, largely on private lands in range and agricultural areas (Tiller et al. 2000). However, one of the core areas used by bulls during the calving period centered on State Route 240 and included part of the Hanford Central Plateau southeast of Area C (Tiller et al. 2000). In addition, elk are known to also move extensively north of State Route 240 (SR 240), east and south of Area C, from fall through spring. Although most of these movements onto the Hanford Central Plateau are located east and south of Area C, elk also have been observed using Area C (e.g., during summer 2002 [see Attachment A to this appendix]). Use of Area C appears to be restricted to foraging and loafing. Calving generally occurs at the upper elevations of Rattlesnake Mountain.

Blasting and use of heavy equipment to remove borrow materials from Area C undoubtedly will disturb elk and displace some animals into adjacent areas, particularly if conducted during the winter months. However, because Area C comprises only a small portion of their overall range and is not known to be particularly important for either overwintering or calving, the effect on the population is likely to be minimal.

Blasting and use of heavy equipment to remove borrow materials from Area C undoubtedly will also disturb the other mammalian species listed above and displace some individuals into adjacent areas. However, because Area C is not known to be particularly important for any of these species, the effects on local populations of these are likely to be minimal.

Area C – Impacts to Plant and Wildlife Species of Concern. According to Soll and Soper (1996), there was a rare plant population of an unnamed species located within Area C, although its purported location did not correspond to any of the areas searched by TNC during the rare plant surveys it conducted on the ALE Reserve in the 1990s. In addition, this population was not referenced in the BRMaP (DOE-RL 2001). This discrepancy was resolved during fieldwork conducted in June and July 2002, during which no rare plant population was observed (Sackschewsky 2002d).

The only plant species of concern observed within the Area C plant communities were purple mat (*Nama densum* var. *parviflorum*), crouching milkvetch, and stalked-pod milkvetch (Attachment A to this appendix; Sackschewsky 2002d). Purple mat is a Washington State Review 1 species (plant taxon of potential concern that is in need of additional field work before a status can be assigned [WNHP 2002]). Review 1 species are considered Level II resources under BRMaP (DOE-RL 2001).

Purple mat occurs occasionally throughout central Hanford (Sackschewsky and Downs 2001). Crouching milkvetch and stalked-pod milkvetch are relatively common on the Central Plateau (Sackschewsky and Downs 2001). Consequently, disturbance of the individuals of these three species located in the Area C plant communities would not likely adversely affect the overall local populations. The Area C plant communities (Figure I.4) in which these three species were observed are provided in Table I.2.

No wildlife species of concern were observed in any of the Area C plant communities (Attachment A to this appendix; Sackschewsky 2002d).

Area C Stockpile Area and Conveyance Road – Impacts to Habitats and Wildlife. The area identified for the stockpile area and conveyance road north of SR 240 was severely burned in the 24 Command Fire. This area continues to be severely eroded by wind (Becker and Sackschewsky 2001a; 2001b; Sackschewsky and Becker 2001). Much of the topsoil, and likely much of the buried seed (Baker 2000), has been removed. Because of a lack of buried seed, relatively long distances to external upwind seed sources, continued wind erosion, and competition by weedy species, sagebrush recovery is expected to be minimal before the start of new construction.

Table I.2. Area C Plant Communities in Which Purple Mat, Crouching Milkvetch, and/or Stalked-Pod Milkvetch Were Observed (Attachment A to this appendix; Sackschewsky 2002d)

Plant Community	Species		
	Crouching Milkvetch	**Purple Mat**	**Stalked-Pod Milkvetch**
Cheatgrass/needle-and-thread grass/Indian ricegrass	(a)	X	X
Needle-and-thread grass/cheatgrass	X		
Sandberg's bluegrass/cheatgrass			
Cheatgrass/Indian ricegrass/Russian thistle			X
Cheatgrass/Sandberg's bluegrass/Jim Hill's tumble mustard	X	X	
Cheatgrass	X		
Cheatgrass/Indian ricegrass	X		
Gray rabbitbrush/cheatgrass			X

(a) Blank cells indicate that the species have not been found in the corresponding plant communities.

The dominant plant species in this area currently are Russian thistle (30 percent), cheatgrass (15 percent), and dune scurfpea (*Psoralea lanceolata*) (10 percent) (Attachment A to this appendix; Sackschewsky 2002d).

Wildlife that could be affected by disturbance of the stockpile and conveyance road area include mammals—the black-tailed jackrabbit and coyote—and birds—the horned lark, mourning dove (*Zenaida macroura*), Western kingbird (*Tyrannus verticalis*), and Western meadowlark (Attachment A to this appendix; Sackschewsky 2002d).

Of these avian species, those that are ground-nesting and that may nest within the stockpile and conveyance road area include the horned lark and Western meadowlark. The same temporal restrictions as set forth above apply for conducting ground-disturbing activities outside the nesting season to protect the nests, eggs, and young of these species in this area.

Area C Stockpile Area and Conveyance Road – Impacts to Plant and Wildlife Species of Concern. The only plant species of concern observed within the area identified for the stockpile and conveyance road was stalked-pod milkvetch (Attachment A to this appendix; Sackschewsky 2002d). Because stalked-pod milkvetch is relatively common on the Central Plateau (Sackschewsky and Downs 2001), disturbance of the individuals located within the stockpile and conveyance road area would not likely adversely affect the overall local population.

Only one wildlife species of concern was observed within this area—the black-tailed jackrabbit (Attachment A to this appendix; Sackschewsky 2002d). Because sagebrush recovery in the area identified for the stockpile and conveyance road is expected to be minimal before the start of new construction, the impact of its eventual removal on the black-tailed jackrabbit within the Columbia Basin is likely to be insignificant.

I.2.2 Alternative Group B

LLBGs in the 200 East Area. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Group B. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Group B.

LLBGs in the 200 West Area. Other potential impacts in addition to those described for habitats and plant and animal species under Alternative Group A may occur under Alternative Group B due to disposal in the 218-W-6 LLBG.

Most of the eastern half of the 218-W-6 LLBG has been previously disturbed and replanted to crested wheatgrass (Brandt 1998, 1999; Sackschewsky 2000, 2001, 2002a). The entire western half and a portion of the eastern half (on the northern edge) of the burial ground had not been disturbed prior to late 2001/2002 and consisted of sagebrush, spiny hopsage (*Grayia spinosa*), and Sandberg's bluegrass. However, these areas also were treated with herbicide during late 2001/early 2002 (Sackschewsky 2002a) prior to anticipated mechanical removal of vegetation (Sackschewsky 2002b) for the purpose of fire suppression.

With the exception of the northeastern corner, the eastern half of the 218-W-6 LLBG receives regular herbicide applications and thus has essentially no habitat value for native species. Vegetation on the western half and the northeastern corner of the 218-W-6 LLBG has been removed since the initial herbicide application of late 2001/2002, and these areas will continue to receive herbicide applications on a regular basis. Thus, they also will have essentially no habitat value for native species. Consequently, continued use of the 218-W-6 LLBG, or new disturbance of the extant plant communities within them, would not result in the loss of any habitats designated by Washington State as priority habitat (DOE-RL 2003). However, native habitats could develop if herbicide spraying ceases.

New Waste Processing Facility – Impacts to Habitats and Wildlife. The area identified for construction of the New Waste Processing Facility consisted of mature sagebrush habitat before the 24 Command Fire. The dominant plant species in this area currently is bur ragweed (*Ambrosia acanthacarpa*), a native annual weed (Attachment A to this appendix).

This area was severely burned and continues to be severely eroded by wind (Becker and Sackschewsky 2001a, 2001b; Sackschewsky and Becker 2001). Much of the topsoil and likely much of the buried seed (Baker 2000) have been removed. Because of a lack of buried seed, relatively long distances to external upwind seed sources, continued wind erosion, and competition by weedy species, sagebrush recovery is expected to be minimal within the time frame before the start of new construction.

Wildlife that could be affected by disturbance of the area identified for construction of the New Waste Processing Facility include the coyote (Attachment A to this appendix).

New Waste Processing Facility – Impacts to Plants and Wildlife Species of Concern. The only plant species of concern observed within the area identified for the New Waste Processing Facility was stalked-pod milkvetch (Attachment A to this appendix). Because stalked-pod milkvetch is relatively common on the Central Plateau (Sackschewsky and Downs 2001), disturbance of the individuals located within the stockpile and conveyance road area would not likely adversely affect the overall local population.

No wildlife species of concern were observed in this area (Attachment A to this appendix).

ILAW Disposal Facility – Impacts to Habitats and Wildlife. The area identified for construction of the ILAW disposal facility was divided into two areas for the summer 2002 field surveys (Attachment A to this appendix; Sackschewsky 2002d)—the W-5 Expansion Area and the area located north of 16th Street and west of Dayton Avenue. Both areas consisted of mature big sagebrush habitat before the 24 Command Fire.

The dominant plant species in the W-5 Expansion Area currently are Sandberg's bluegrass (20 percent), cheatgrass (15 percent), Indian ricegrass (10 percent), and Russian thistle (10 percent) (Attachment A to this appendix; Sackschewsky 2002d). The dominant plant species in the area located north of 16th Street and west of Dayton Avenue currently is Russian thistle (Attachment A to this appendix; Sackschewsky 2002d).

Wildlife that could be affected by disturbance of the W-5 Expansion Area include mammals—the badger, coyote, Great Basin pocket mouse, and mule deer; and birds—the horned lark, mourning dove, and Western meadowlark (Attachment A to this appendix; Sackschewsky 2002d). Only the coyote and Western meadowlark were observed in the area north of 16th Street and west of Dayton Avenue (Attachment A to this appendix; Sackschewsky 2002d).

Of these avian species, those that are ground-nesting and that may nest within the W-5 Expansion Area and the area located north of 16th Street and west of Dayton Avenue include the horned lark and Western meadowlark. The same temporal restrictions as set forth above apply for conducting ground-disturbing activities outside the nesting season to protect the nests, eggs, and young of these species in these areas.

The W-5 Expansion Area and the area north of 16th Street and west of Dayton Avenue were severely burned and continue to be severely eroded by wind (Becker and Sackschewsky 2001a, 2001b; Sackschewsky and Becker 2001). Much of the topsoil and likely much of the buried seed (Baker 2000) have been removed. Because of a lack of buried seed, relatively long distances to external upwind seed sources, continued wind erosion, and competition by weedy species, sagebrush recovery is expected to be minimal within the time frame before the start of new construction.

ILAW Disposal Facility – Impacts to Plant and Wildlife Species of Concern. The only plant species of concern observed in the W-5 Expansion Area were crouching milkvetch, stalked-pod milkvetch, and purple mat (Attachment A to this appendix; Sackschewsky 2002d). Crouching milkvetch and purple mat were the only plant species of concern observed in the area north of 16th Street and west of Dayton Avenue (Attachment A to this appendix; Sackschewsky 2002d). Because purple mat occurs occasionally throughout central Hanford, and crouching milkvetch and stalked-pod milkvetch are relatively common on the Central Plateau (Sackschewsky and Downs 2001), disturbance of the individuals of these three species located in the W-5 Expansion Area and the area north of 16th Street and west of Dayton Avenue would not likely adversely affect the overall local populations.

No wildlife species of concern were observed in the W-5 Expansion Area and the area located north of 16th Street and west of Dayton Avenue (Attachment A to this appendix; Sackschewsky 2002d).

Area C. No other impacts to habitats and species in addition to those described under Alternative Group A are expected to occur under Alternative Group B. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Group B.

Area C Stockpile Area and Conveyance Road. No other impacts to habitats and species in addition to those described under Alternative Group A are expected to occur under Alternative Group B. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Group B.

I.2.3 Alternative Group C

LLBGs in the 200 East Area and 200 West Area. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Group C. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Group C.

Proposed Disposal Facility Near PUREX in 200 East Area. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Group C. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Group C.

Area C. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Group C. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Group C.

Area C Stockpile Area and Conveyance Road. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Group C. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Group C.

I.2.4 Alternative Groups D_1, D_2, and D_3

LLBGs in the 200 East Area and 200 West Area. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Groups D_1, D_2, or D_3. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Groups D_1, D_2, or D_3.

Proposed Disposal Facility Near PUREX in 200 East Area. Proposed disposal near the PUREX Plant occurs only under Alternative Group D_1. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Group D_1. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Group D_1.

ERDF – Impacts to Habitats and Plant Species of Concern. Disposal in the ERDF occurs only under Alternative Group D_3. The majority of the ERDF site has not been completely surveyed. The ERDF site and some of the surrounding area was burned in the 24 Command Fire. The area comprising the ERDF site before the 24 Command Fire generally consisted of mature sagebrush habitat with varying understory components. The dominant understory component over approximately 90 percent of the area was a mix of cheatgrass and Sandberg's bluegrass. The dominant understory component over approximately 10 percent of the area was a mix of cheatgrass and needle-and-thread grass (DOE-RL 1995c).

A winter survey of a previously contemplated ERDF rail line was conducted in 1993. Sections 4 and 5 of the rail line fell within the northern half of the ERDF site (Brandt 1994). The plant species observed within these two sections at that time are provided in Brandt (1994). The dominant overstory species at that time was sagebrush at 25 percent to 50 percent cover, and the dominant understory species was cheatgrass at 50 percent to 75 percent cover. The only observed plant species of concern was the stalked-pod milkvetch.

This field survey covered only a relatively small portion of the ERDF site and was conducted outside the growing season for most herbaceous plants and prior to the 24 Command Fire of June 2000. Consequently, a spring 2003 field survey is planned to completely characterize the current habitat associations and plant species on the ERDF site.

ERDF – Impacts to Wildlife and Wildlife Species of Concern. Wildlife species observed along the previously contemplated ERDF rail line are summarized for the entire line in Brandt (1994). The only evidence of species of concern observed within the ERDF site were inactive nests of the loggerhead shrike (*Lanius ludovicianus*), a Washington State candidate species and a federal species of concern (species whose conservation standing is of concern to the U.S. Fish and Wildlife Service but for which status information still is needed).

This field survey covered only a relatively small portion of the ERDF site, was conducted outside the period of residence of migratory birds and during the period of hibernation of most mammals, and occurred prior to the 24 Command Fire. Consequently, a spring 2003 field survey is planned to completely characterize current wildlife use of the ERDF site.

Area C. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Groups D_1, D_2, or D_3. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Groups D_1, D_2, or D_3.

Area C Stockpile Area and Conveyance Road. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Groups D_1, D_2, or D_3. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Groups D_1, D_2, or D_3.

I.2.5 Alternative Groups E_1, E_2, and E_3

LLBGs in the 200 East Area and 200 West Area. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Groups E_1, E_2, or E_3. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Groups E_1, E_2, or E_3.

Proposed Disposal Facility Near PUREX in 200 East Area. Proposed disposal near the PUREX Plant occurs only under Alternative Groups E_2 and E_3. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Groups E_2 or E_3. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Groups E_2 or E_3.

ERDF. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group D_3 are expected to occur under Alternative Groups E_1, E_2, or E_3. No other field surveys in addition to those described under Alternative Group D_3 would be required under Alternative Groups E_1, E_2, or E_3.

Area C. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Groups E_1, E_2, or E_3. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Groups E_1, E_2, or E_3.

Area C Stockpile Area and Conveyance Road. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under Alternative Groups E_1, E_2, or E_3. No other field surveys in addition to those described under Alternative Group A would be required under Alternative Groups E_1, E_2, or E_3.

I.2.6 No Action Alternative

LLBGs in the 200 East Area and 200 West Area. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under the No Action Alternative. No other field surveys in addition to those described under Alternative Group A would be required under the No Action Alternative.

Proposed Disposal Facility Near PUREX in 200 East Area. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under the No Action Alternative. No other field surveys in addition to those described under Alternative Group A would be required under the No Action Alternative.

Additional CWC Buildings. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group B are expected to occur under the No Action Alternative. No other field surveys in addition to those described under Alternative Group B would be required under the No Action Alternative.

Area C. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under the No Action Alternative. No other field surveys in addition to those described under Alternative Group A would be required under the No Action Alternative.

Area C Stockpile Area and Conveyance Road. No other impacts in addition to those described for habitats and plant and animal species under Alternative Group A are expected to occur under the No Action Alternative. No other field surveys in addition to those described under Alternative Group A would be required under the No Action Alternative.

I.2.7 Mitigation

Most biological resources in the Industrial-Exclusive Area of the 200 Areas Plateau were destroyed or displaced during the 24 Command Fire. However, some habitats and species would be subject to mitigation under existing biological conditions and current mitigation guidelines, as prescribed in BRMaP (DOE-RL 2001) and the *Hanford Site Biological Resources Mitigation Strategy* (BRMiS) (DOE-RL 2003).

This section sets forth what the current mitigation requirements for these habitats/species would be if these were to be disturbed in their current condition under current mitigation guidelines. This is done for the purpose of comparison among the alternative groups because current biological conditions and mitigation guidelines are inappropriate for determining actual mitigation requirements for impacts that would not occur for at least another decade. In the interim, habitats and species assemblages may change (e.g., fire-damaged habitats may recover), as might mitigation guidelines at Hanford. Consequently, actual mitigation requirements will depend on the results of field surveys conducted during the growing season just prior to initiating operations, as well as on the mitigation guidelines in effect at Hanford at that time.

According to BRMaP (DOE-RL 2001), mitigation should be considered for biological resources categorized as Level II and above (Table I.3). The current mitigation requirements for the Level II and above resources described in the preceding sections are discussed below.

Level I Habitat Resources. All habitats described in the preceding sections that were not designated Level II or above are considered Level I resources, and no mitigation is required (Table I.3) (DOE-RL 2001).

Level II Habitat Resources. Mitigation of Level II habitat resources generally is accomplished by avoidance and impact minimization (Table I.3). However, in some cases where Level II resources fall into the category of recovering shrub-steppe habitat, and field surveys of the affected area confirm that

Table I.3. General Classes of Mitigation Actions and Biological Resource Levels of Concern to Which They Apply (DOE-RL 2001)

Class of Mitigation Action	Resource Level[(a)]			
	I	II	III	IV
Avoidance[(b)]/Minimization[(c)]	No	Yes	Yes	Yes
Replacement by Rectification[(d)]/Compensation[(e)]	No	No	Yes	Yes[(f)]

(a) See Table I.1 for resource level definitions.
(b) Avoidance = eliminate all or part of a project or alter the timing, location, or implementation to avoid injury to biological resources of concern.
(c) Minimization = alter project timing, location, or implementation to minimize injury to biological resources of concern.
(d) Rectification = replace biological resources of concern on the site to be disturbed.
(e) Compensation = replace lost biological resources of concern away from the site to be disturbed.
(f) Rectification is probably not possible nor an appropriate means of mitigation at this level; compensatory mitigation can be used but only when it is achieved by acquisition and/or protection of in-kind resources.

sagebrush recovery (defined as sagebrush habitat with immature sagebrush regenerated through natural processes) is well under way, replacement mitigation (rectification or compensation [Table I.3]) is recommended (DOE-RL 2001).

Replacement mitigation for disturbance of the widely scattered mature big sagebrush located in the southeastern portion of the cheatgrass/Sandberg's bluegrass/Jim Hill's tumble mustard community in Area C (see Figure I.4) is not recommended. Because no immature sagebrush was observed during the summer 2002 field survey (Sackschewsky 2002d), sagebrush recovery is not currently occurring, by definition. Nonetheless, this habitat would be subject to mitigation via avoidance and impact minimization (Table I.3).

Replacement mitigation for disturbance of the sagebrush habitat within the gray rabbitbrush/cheatgrass community in Area C (see Figure I.4) is not required. The sagebrush within this community occurs over an area smaller than the current mitigation threshold for the 600 Area (0.5 ha [1.25 ac]) (DOE-RL 2003), and it covers only 1 percent of the area in which it occurs, which is much less than the current mitigation requirement of at least 10 percent cover (DOE-RL 2003). Nonetheless, this habitat would be subject to mitigation via avoidance and impact minimization (Table I.3).

Level III Habitat Resources. Disturbance of 5 ha or more of mature sagebrush habitat is the mitigation threshold in the southern half of the 200 East Area (DOE-RL 2003). Mitigation for disturbance of the mature sagebrush habitat on the site of the proposed disposal facility near PUREX would first be by avoidance and impact minimization. However, when avoidance and impact minimization are not possible or their application still results in adverse residual impacts above 5 ha, as would be the case in construction of the disposal facility, replacement mitigation is required (DOE-RL 2001).

Level IV Habitat Resources. Element occurrences are defined as Level IV resources (see Table I.1) because they are of such high quality (i.e., they show little or no indication of human impact or invasion by non-native species, or they have significant wildlife usage) and/or rarity that they cannot be mitigated unless it is by compensation via the setting aside and protection of in-kind (i.e., similar type and quality) resources (DOE-RL 2001). There are three element occurrences in Area C. Mitigation recommendations for these follow.

The cheatgrass/needle-and-thread grass/Indian ricegrass community (Figure I.4) is an element occurrence of the bitterbrush/Indian ricegrass sand dune complex community type (Figure I.3). Disturbance of the cheatgrass/needle-and-thread grass/Indian ricegrass community would be mitigated via the setting aside and protection of an element occurrence of the bitterbrush/Indian ricegrass sand dune complex community type located away from Area C. The size of the replacement community should approximate that of the lost community, 97 ha (241 ac). Ample element occurrences of this community type currently exist elsewhere in the 600 Area of the Hanford Site to satisfy this size constraint (Figure I.5).

The needle-and-thread grass/cheatgrass community (Figure I.4) is an element occurrence of the sagebrush/needle-and-thread grass community type (Figure I.3). Disturbance of the needle-and-thread grass/ cheatgrass community would be mitigated via the setting aside and protection of an element occurrence of the sagebrush/needle-and-thread grass community type located away from Area C. The size of the replacement community should approximate that of the lost community, 5 ha (12.5 ac). Ample element occurrences of this community type currently exist elsewhere in the 600 Area of the Hanford Site to satisfy this size constraint (Figure I.6).

The Sandberg's bluegrass/cheatgrass community (Figure I.4) is an element occurrence of the big sagebrush/bluebunch wheatgrass community type (Figure I.3). Disturbance of the Sandberg's bluegrass/ cheatgrass community would be mitigated via the setting aside and protection of an element occurrence of the big sagebrush/bluebunch wheatgrass community type. The size of the replacement community should approximate that of the lost community, 1.5 ha (4 ac). Element occurrences of this community type within the 600 Area are currently limited to Gable Mountain and the north side of Vernita Quarry (Figure I.7).

Level I Species Resources. Crouching milkvetch (located in the 218-E-10 and 218-E-12B LLBGs in the 200 East Area and in Area C) and stalked-pod milkvetch (located in the 218-W-5 LLBG in the 200 West Area, Area C, the stockpile area and conveyance road area, the area designated for the new processing facility, and ERDF) are considered Watch List species by Washington State, the lowest level of listing for plant species of concern in the state. Watch List species are thus considered Level I resources under BRMaP, for which no mitigation is required (Table I.3) (DOE-RL 2001).

Level II Species Resources. Purple mat (located in Area C) is considered a Washington State Review 1 species. Review 1 species are considered Level II resources under BRMaP, for which mitigation requirements consist of avoidance and impact minimization (Table I.3) (DOE-RL 2001).

Level III Species Resources. Piper's daisy was formerly present in the 218-E-12B and 218-E-10 LLBGs in the 200 East Area. Mitigation for this species would not currently be required because it is now absent in the areas where it formerly occurred. However, mitigation would be considered if populations were to recover prior to initiating operations. Therefore, the presence/absence of Piper's

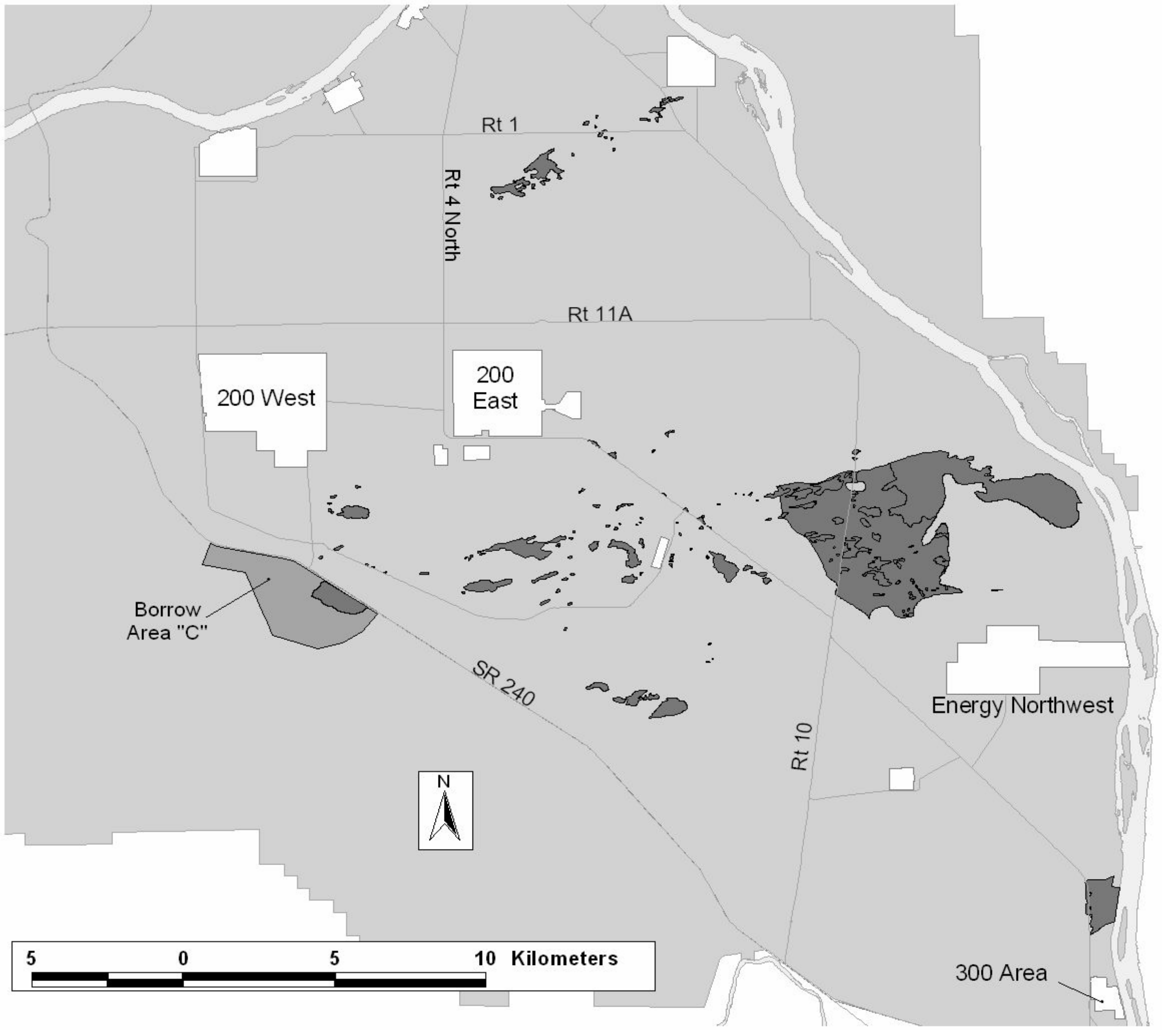

Figure I.5. Element Occurrences of Bitterbrush/Indian Ricegrass Sand Dune Complex Community Type Outside Area C in 600 Area of Hanford Site

daisy populations on the 218-E-12B and 218-E-10 LLBGs should be determined via a field survey during the growing season just prior to initiating operations.

Summary. The habitats and species that are subject to mitigation based on existing conditions and current mitigation guidelines are summarized by alternative group in Table I.4. All habitats/species subject to mitigation, with their associated mitigation actions, occur in each of the alternative groups, with the exception of the mature sagebrush habitat at the site of the proposed disposal facility near PUREX (Table I.4). Consequently, the alternative groups can be differentiated only with respect to mitigation of this habitat.

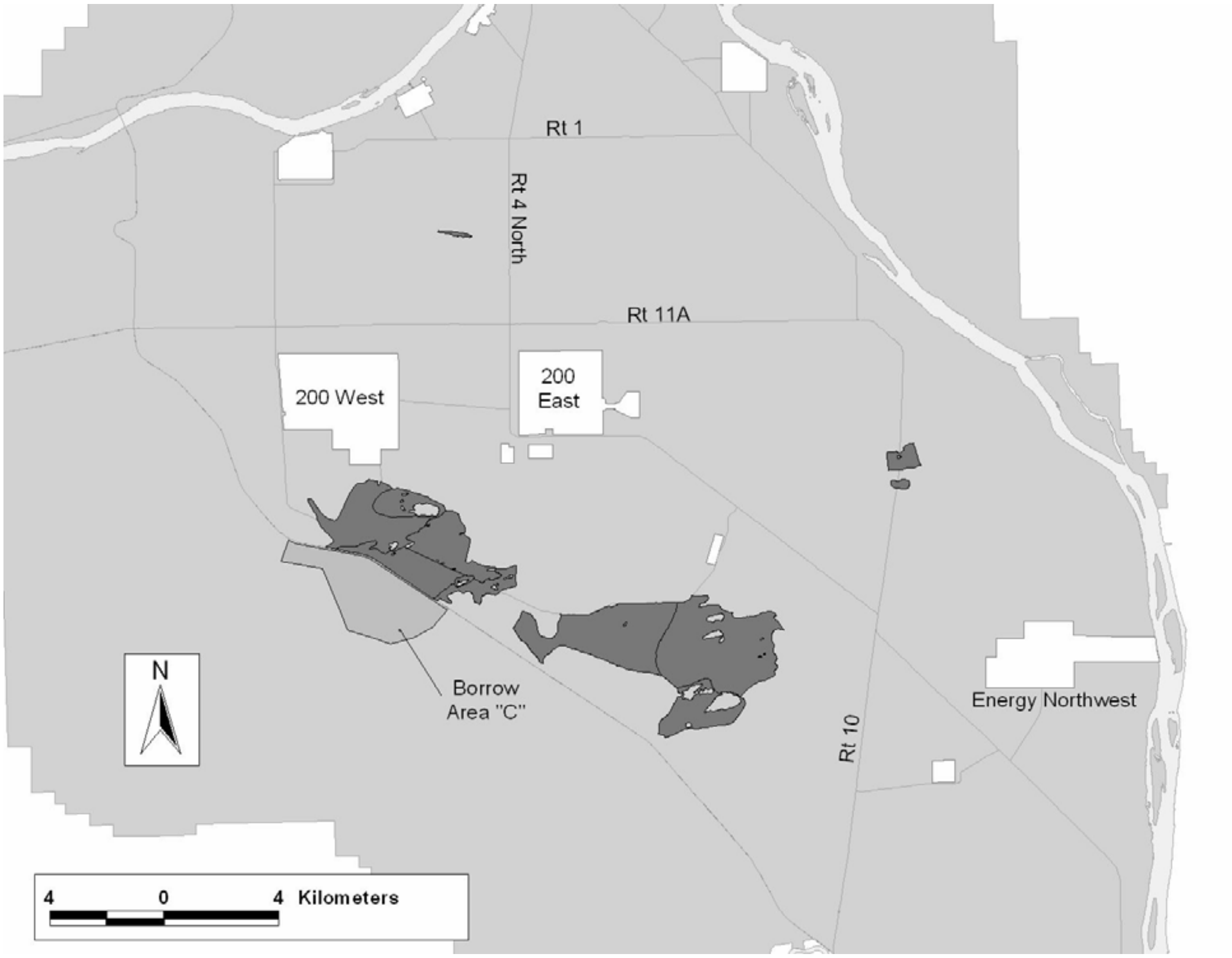

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Figure I.6. Element Occurrences of Big Sagebrush/Needle-and-Thread Grass Community Type Outside Area C in 600 Area of Hanford Site

The aerial extent of disturbance of the mature sagebrush habitat in the proposed disposal facility near PUREX varies by alternative group (Table I.4), and so would the corresponding mitigation requirements. Thus, the areas of disturbance may be used to differentiate the alternative groups. These are provided in Table 5.1 in Section 5.1 of this Hanford Solid Waste Environmental Impact Statement (HSW EIS)

I.2.8 Biodiversity

The potential effects on biodiversity that might result from the waste management and related operations described in this HSW EIS are best considered on an ecosystem or regional scale (CEQ 1993). The Hanford Site is located within the Columbia Basin ecoregion, an area that historically included over 6 million ha (14.8 million ac) of steppe and shrub-steppe vegetation across most of central and southeastern Washington State, as well as portions of north-central Oregon. The pre-settlement vegetation consisted primarily of shrubs, perennial bunchgrasses, and a variety of forbs. An estimated

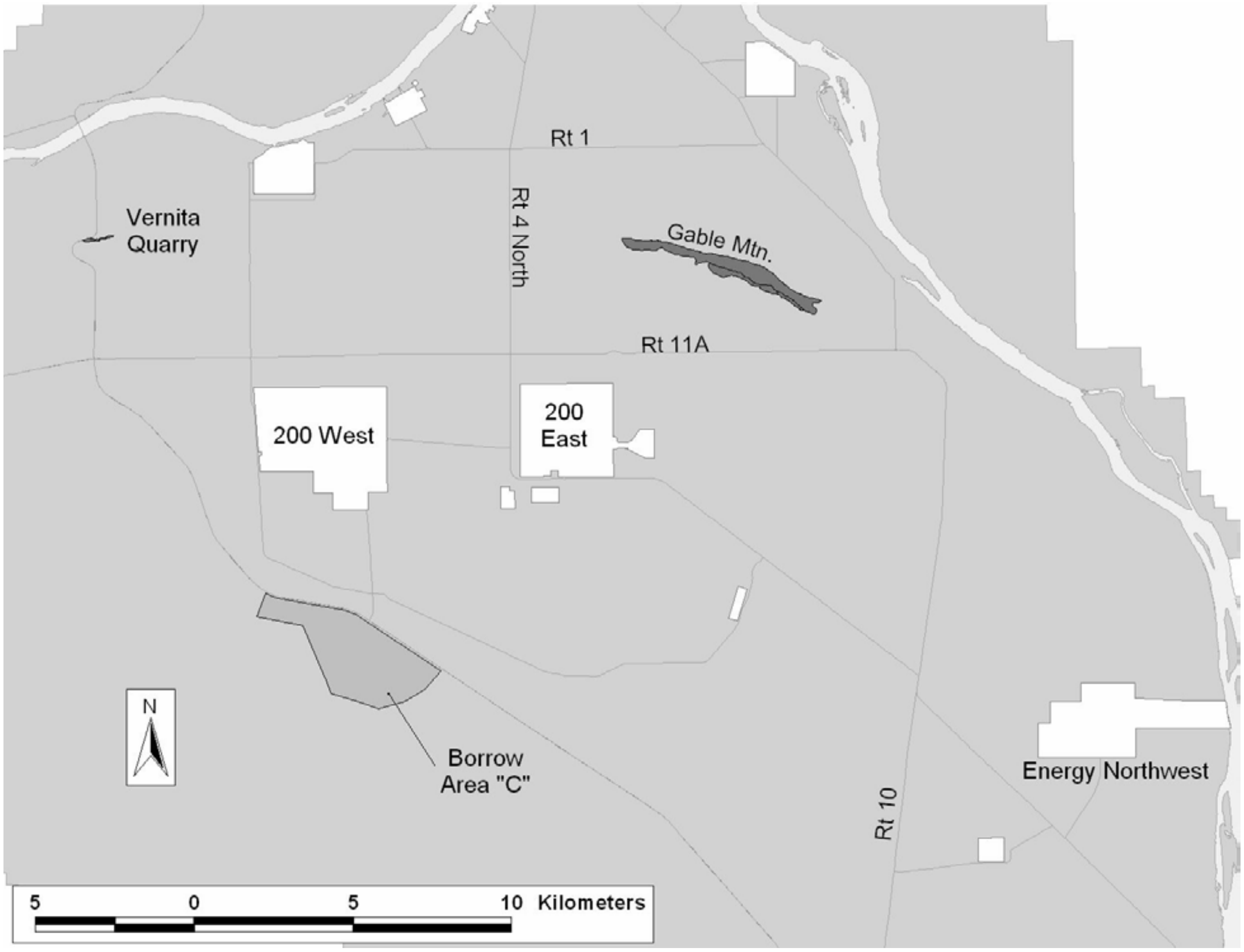

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Figure I.7. Element Occurrences (on Gable Mountain and at Vernita Quarry) of Big Sagebrush/ Bluebunch Wheatgrass Community Type Outside Area C in 600 Area of Hanford Site

60 percent of shrub-steppe in Washington has been converted to agriculture or other uses. Much of what remains is in small parcels, in shallow rocky soils, or has been degraded by historic land uses (mostly livestock grazing) (TNC 1999).

The Hanford Site retains some of the largest remaining blocks of relatively undisturbed shrub-steppe in the Columbia Basin ecoregion. Hanford's importance as a refuge for the shrub-steppe ecosystem is not solely size-related, however. The presence of a high diversity of physical features and examples of rare, undeveloped deep and sandy soil has led to a corresponding diversity of plant and animal communities. Many places on the Hanford Site are relatively free of non-native species and are extensive enough to retain characteristic populations of shrub-steppe plants and animals that are absent or scarce in other areas. Because of its location, the site provides important connectivity with other undeveloped portions of the ecoregion (TNC 1999).

Table I.4. Habitats and Species Subject to Mitigation Based on Existing Conditions and Current Mitigation Guidelines

EIS Alternative Group(s)	Habitat/Species	Resource Ranking	Location	Area (ha [ac])	Class of Mitigation Action
Alternatives A, B, C, D_1, D_2, D_3, E_1, E_2, E_3, and No Action	Purple mat	II	Area C	NA	Avoidance/minimization
Alternatives A, B, C, D_1, D_2, D_3, E_1, E_2, E_3, and No Action	Widely scattered mature big sagebrush in the southeastern portion of the cheatgrass/Sandberg's bluegrass/Jim Hill's tumble mustard community	II	Area C	Unknown	Avoidance/minimization
Alternatives A, B, C, D_1, D_2, D_3, E_1, E_2, E_3, and No Action	Sagebrush habitat within the gray rabbitbrush/cheatgrass community	II	Area C	<0.5 (1.25)	Avoidance/minimization
Alternatives A, C, D_1, E_2, E_3, and No Action	Mature sagebrush steppe	III	Site of the proposed disposal facility near PUREX	Varies by alternative group[(a)]	Avoidance/minimization or rectification/compensation
Alternatives A, B, C, D_1, D_2, D_3, E_1, E_2, E_3, and No Action	Cheatgrass/needle-and-thread grass/Indian ricegrass community (element occurrence of the bitterbrush/Indian ricegrass sand dune complex community type)	IV	Area C	97 (241)	Compensation -- setting aside and protection of in-kind resources
Alternatives A, B, C, D_1, D_2, D_3, E_1, E_2, E_3, and No Action	Needle-and-thread grass/cheatgrass community (element occurrence of the sagebrush/needle-and-thread grass community type	IV	Area C	5 (12.5)	Compensation – setting aside and protection of in-kind resources
Alternatives A, B, C, D_1, D_2, D_3, E_1, E_2, E_3, and No Action	Sandberg's bluegrass/cheatgrass community (element occurrence of the big sagebrush/bluebunch wheatgrass community type	IV	Area C	1.5 (4)	Compensation – setting aside and protection of in-kind resources

(a) The area of mature sagebrush habitat to be disturbed varies depending on alternative group, ranging from about 5 ha (12 ac) for the Hanford Only waste volume of Alternative Group E_2 to 32 ha (79 ac) for Alternative Group A.

The 24 Command Fire removed virtually all the shrub-steppe on areas (outside the LLBGs) that would be disturbed by new construction described in the HSW EIS (i.e., Area C and the areas identified for construction of the additional CWC facilities and the New Waste Processing Facility). Plant communities in these areas now are dominated largely by exotic, invasive "weedy" species and support only relatively common and generally ubiquitous plant and animal taxa that are not characteristic of shrub-steppe (see Sections I.2.1–3 and Attachment A to this appendix). These plant and animal taxa are relatively unimportant in terms of their contribution to the maintenance of ecoregional biodiversity. In addition, the 24 Command Fire removed most of the adjacent shrub-steppe, interrupting the connectivity of these areas with other undeveloped portions of the ecoregion.

Prior to the start of new construction as described in the HSW EIS, re-colonization by characteristic shrub-steppe plants and animals in these (and adjacent) areas may occur. The need for mitigation of ecological impacts in these areas would depend on the results of surveys conducted just prior to initiating operations because those operations are not expected for a decade or more. Biological resources would be subject to mitigation based on existing conditions and applicable mitigation guidelines at that time, such as the *Hanford Site Biological Resources Management Plan* (DOE-RL 2001) and the *Hanford Site Biological Resources Mitigation Strategy* (DOE-RL 2003). Although new construction would result in temporary habitat loss in these areas, its loss would likely have no long-term effect on ecoregional biodiversity.

I.2.9 Microbiotic Crusts

Microbiotic (cryptogamic) crusts generally occur in the top 1 to 4 mm of soil and are formed by living organisms and their by-products, creating a crust of soil particles bound together by organic materials. These crusts are common in the semi-arid Columbia Basin, where they tend to be dominated by green algae (Johansen et al. 1993). The functions of microbiotic crusts include soil stability and erosion, fixation of atmospheric nitrogen, nutrient contributions to plants, soil-plant water relations, water infiltration, seedling germination, and plant growth.

The relative importance of biological crusts and their ecological roles is highly dependent on the relative cover of various crustal components. Carbon inputs are higher when mosses and lichens are present than when crust is dominated by cyanobacteria. Nitrogen inputs are higher with greater infiltration and soil surface stability, which are related to cyanobacterial biomass as well as moss and lichen cover (Belnap et al. 2001). The lichens and mosses of the Hanford Site were surveyed and evaluated by Link et al. (2000). They found 29 soil lichen species in 19 genera, comprising four different growth forms, and 6 moss species in 4 genera.

Disruption of microbiotic crusts may result in decreased diversity of microbiota, soil nutrients, and organic matter (Belnap and Harper 1995, Belnap et al. 2001). The 24 Command Fire intensely burned the soil surface in areas (outside the LLBGs) that would be disturbed by new construction as described in the HSW EIS. This undoubtedly resulted in the virtual complete destruction of soil microbiota, facilitating the severe wind erosion experienced in these areas (Becker and Sackschewsky 2001a, 2001b; Sackschewsky and Becker 2001). Recovery of microbiotic crusts following disturbance is generally a slow process. For example, in burned areas on the ALE Reserve, soil algae recovery took place during the winter months of the second year following the fire of 1984 (Johansen et al. 1993). The recovery time required by soil microbiota following construction is no exception.

Although microbiotic crusts may tolerate shallow burial, deep burial such as would result from construction described in the HSW EIS will kill crusts (Shields et al. 1957). Re-colonization of Area C and the areas identified for the additional CWC facilities and the New Waste Processing Facility would undoubtedly require several years following construction, the speed of which may largely depend on the availability of nearby sources (Belnap 1993). Consequently, a temporary loss of benefits derived from microbiotic crusts would ensue.

I.3 Impacts to Columbia River Aquatic and Riparian Resources Resulting from Future Contaminant Releases

Potential adverse impacts posed by future releases of contaminants to aquatic and terrestrial species known to occur in the Columbia River and its riparian corridor were analyzed in an ecological risk assessment framework. The risk assessments conducted for this analysis of impacts generally follow U.S. Environmental Protection Agency (EPA) guidance for conducting such assessments (EPA 1992, 1998) and the corresponding Hanford Site risk assessment methodology (DOE-RL 1995b).

These risk assessments emphasize the analysis and risk characterization phases of the EPA risk assessment paradigm, in order to characterize the relative magnitude of potential impacts between the alternative groups. The problem formulation phase of the EPA risk assessment framework is not well represented in these risk assessments because the inventory, location, release, and migration of contaminants of interest to the Columbia River are covered elsewhere in the EIS.

The risk of future adverse effects was analyzed using the Ecological Contaminant Exposure Model (ECEM) (Eslinger et al. 2002) developed for the Columbia River Comprehensive Impact Assessment (DOE-RL 1998).

I.3.1 Assumptions Regarding Contaminants

Contaminant concentrations used in the risk assessment consisted of predicted peak concentrations of key radionuclides at a hypothetical well along the Columbia River during any given year within 10,000 years of 2046 (see Appendix G). These well concentrations were assumed to apply also to pore water (water in the interstitial spaces of the substrate that forms the bottom of the Columbia River, such as groundwater in springs between rocks). Predicted peak concentrations of key radionuclides in the river also were used. These were derived from maximum amounts of radionuclides entering the river within the affected area in any 10-year period within 10,000 years of 2046 (see Appendix G). River concentrations were derived by diluting the maximum amount of a radionuclide by the average volume of river flow within a generic 10-year period (based on an average annual flow rate of 3300 m^3/sec).

The 10,000 years were divided into two time periods, early and late. An individual risk assessment was performed for each time period within each alternative group. The early time period applies to the radionuclides with a distribution or partition coefficient (K_d) of zero—technetium-99 and iodine-129—whose arrival times at the river well and river are less than 2500 years. The late time period applies to the radionuclides with a K_d greater than zero—carbon-14 and the uranium isotopes—whose arrival times are from 2500 to 10,000 years.

Concentrations of individual radionuclides were summed over the 200 West Area and 200 East Area source areas and over all waste categories within each time period and alternative group. Concentrations of technetium-99 and iodine-129 in grouted Category 3 LLW and ungrouted Category 1 LLW within each alternative group were combined if their arrival times were within the same time period.

Concentrations of radionuclides often were separated temporally within a given time period and alternative group. For example, arrival times of the same radionuclide at a given location—that is, at the well or river—varied depending on the source area and waste stream (see Appendix G). Further, the same radionuclide from the same source area and waste stream arrived later at the river than at the well (see Appendix G), generally on the order of decades.

Concentrations of radionuclides also were separated spatially within a given time period and alternative group. For example, well concentrations represented a single location whose position varied depending on the radionuclide, source area, or waste stream. In contrast, river concentrations represented the entire length of the river in the affected area downstream from the point of entry.

The assumptions just described in the five foregoing paragraphs underly the radionuclide concentrations used in the risk assessments. These assumptions render the assessments extremely conservative by assuming simultaneous exposure to maximum contaminant concentrations that, based on groundwater modeling (see Appendix G), do not always occur concurrently in time and space. Thus, the risk assessments estimate maximum possible exposure and risk for receptors.

I.3.2 Assumptions Regarding Partitioning of Contaminants to Abiotic Media

Two exposure scenarios were evaluated—Hanford contribution (hereafter expressed as Hanford) and Hanford plus background. The assumptions used to derive the abiotic media concentrations used in these two scenarios are summarized in Table I.5.

In both scenarios, radionuclide concentrations in the well are released from groundwater into shoreline seeps, and the background groundwater contribution is assumed to be zero (Table I.5). Because seeps are located below the high water mark and river water levels fluctuate substantially, seep concentrations are based on mixing groundwater and surface water at a ratio of approximately 0.48:0.52, respectively (Table I.5) (Bryce et al. 2002). Background surface water concentrations for iodine-129, technetium-99, and uranium-234, -235, -236, and -238 were obtained from Kincaid et al. (2000). Background surface water concentrations for carbon-14 were obtained from DOE (1998). Soil concentrations were calculated by multiplying seep concentrations by partition coefficients (K_d). Background pore water concentrations were assumed equal only to background surface water concentrations (Table I.5) because the background groundwater contribution is assumed to be zero.

Table I.5. Summary of Assumptions Used to Derive Abiotic Media Concentrations Used in Hanford and Hanford Plus Background Exposure Scenarios

Exposure Scenario	
Hanford Contribution	**Hanford Contribution Plus Background**
Groundwater = peak concentrations of key radionuclides in well water (Appendix G)	Groundwater = peak concentrations of key radionuclides in well water (Appendix G)
Seep water = mix of 48% groundwater and 52% surface water	Seep water = mix of 48% groundwater and 52% surface water (including background surface water concentrations)
Soil = Seep water × K_d	Soil = Seep water × K_d
Pore water = groundwater	Pore water = groundwater + background surface water concentrations
Sediment = pore water × K_d	Sediment = pore water × K_d
Surface water = maximum concentrations entering the river (Appendix G) diluted by average river flow volume within a generic 10-year period	Surface water = maximum concentrations entering the river (Appendix G) + background surface water concentrations diluted by average river flow volume within a generic 10-year period

Sediment concentrations were calculated by multiplying pore water concentrations by partition coefficients (K_d). Best estimates were used for soil and sediment K_d values. These were obtained from Table G.1 in Appendix G.

Hanford and Hanford plus background radionuclide and total uranium concentrations in the various abiotic media, as calculated, are presented for each time period and alternative group in Tables I.6 and I.7.

I.3.3 Ecological Contaminant Exposure Model

The Ecological Contaminant Exposure Model, or ECEM, consists of two parts, terrestrial and aquatic (Eslinger et al. 2002). The terrestrial portion estimates wildlife exposures to contaminants in air through inhalation, in water through dermal exposure and ingestion, in soil through dermal exposure and ingestion, and in foods. The aquatic portion estimates exposures to contaminants in surface water and pore water via gill or respiratory uptake, in sediment via dermal exposure and ingestion, and in foods.

The ECEM was developed earlier for other more complex risk assessments of Columbia River biota (DOE-RL 1998; Bryce et al. 2002) and thus is based on a food web architecture that is specific to the Hanford Site. The ECEM estimates exposures for 57 terrestrial and aquatic animal and plant receptors (Table I.8). One of the ECEM's aquatic receptors, the generic salmon, serves as a surrogate for the steelhead (*Oncorhynchus mykiss* [federal endangered species, Washington State candidate species]) because its conceptual exposure to contaminated abiotic media and prey are essentially the same.

Table I.6. Hanford and Hanford Plus Background Radionuclide Concentrations in Well Water, Pore Water, Sediment, Soil, and River Water for Each Time Period and Alternative Group. Values were calculated based on the assumptions presented in Sections I.3.1 and I.3.2.

Constituent	EIS Alternative Group and Waste Volume	Time Period (y)	Hanford Concentrations					Hanford plus Background Concentrations				
			Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil (pCi/kg)	River Water (pCi/L)	Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil (pCi/kg)	River Water (pCi/L)
C-14	A -- Hanford Only	10,000	0.265890795	0.265890795	0	0	1.69752E-06	0.265890809	1.46589	0	0	1.2
C-14	A -- Lower Bound	10,000	0.265890923	0.265890923	0	0	1.69752E-06	0.26589092	1.46589	0	0	1.2
C-14	A -- Upper Bound	10,000	0.267090409	0.267090409	0	0	1.69828E-06	0.267090405	1.46709	0	0	1.2
C-14	B -- Hanford Only	10,000	0.266099826	0.266099826	0	0	3.33669E-06	0.266099837	1.4661	0	0	1.2
C-14	B -- Lower Bound	10,000	0.266119354	0.266119354	0	0	9.15302E-06	0.266119349	1.46612	0	0	1.20001
C-14	B -- Upper Bound	10,000	0.267447286	0.267447286	0	0	7.90261E-05	0.267447287	1.46745	0	0	1.20008
C-14	C -- Hanford Only	10,000	0.265890795	0.265890795	0	0	1.69752E-06	0.265890809	1.46589	0	0	1.2
C-14	C -- Lower Bound	10,000	0.265890923	0.265890923	0	0	1.69752E-06	0.26589092	1.46589	0	0	1.2
C-14	C -- Upper Bound	10,000	0.266063574	0.266063574	0	0	1.69828E-06	0.266063588	1.46606	0	0	1.2
C-14	D1 -- Hanford Only	10,000	0.266233177	0.266233177	0	0	1.70191E-06	0.266233174	1.46623	0	0	1.2
C-14	D1 -- Lower Bound	10,000	0.266298743	0.266298743	0	0	1.70268E-06	0.266298733	1.4663	0	0	1.2
C-14	D1 -- Upper Bound	10,000	0.269832422	0.269832422	0	0	1.63511E-05	0.269832434	1.46983	0	0	1.20002
C-14	D2 -- Hanford Only	10,000	0.266562402	0.266562402	0	0	1.69936E-06	0.266562411	1.46656	0	0	1.2
C-14	D2 -- Lower Bound	10,000	0.266705953	0.266705953	0	0	1.69976E-06	0.266705963	1.46671	0	0	1.2
C-14	D2 -- Upper Bound	10,000	0.274228089	0.274228089	0	0	1.72075E-06	0.274228085	1.47423	0	0	1.2
C-14	D3 -- Hanford Only	10,000	0.265827158	0.265827158	0	0	1.69716E-06	0.265827166	1.46583	0	0	1.2
C-14	D3 -- Lower Bound	10,000	0.265827158	0.265827158	0	0	1.69716E-06	0.265827166	1.46583	0	0	1.2
C-14	D3 -- Upper Bound	10,000	0.265979635	0.265979635	0	0	1.69781E-06	0.265979627	1.46598	0	0	1.2
C-14	E1 -- Hanford Only	10,000	0.266562402	0.266562402	0	0	1.69936E-06	0.266562411	1.46656	0	0	1.2
C-14	E1 -- Lower Bound	10,000	0.266705953	0.266705953	0	0	1.69976E-06	0.266705963	1.46671	0	0	1.2
C-14	E1 -- Upper Bound	10,000	0.274228089	0.274228089	0	0	1.72075E-06	0.274228085	1.47423	0	0	1.2
C-14	E2 -- Hanford Only	10,000	0.266233177	0.266233177	0	0	1.70191E-06	0.266233174	1.46623	0	0	1.2
C-14	E2 -- Lower Bound	10,000	0.266298743	0.266298743	0	0	1.70268E-06	0.266298733	1.4663	0	0	1.2
C-14	E2 -- Upper Bound	10,000	0.269832422	0.269832422	0	0	1.74291E-06	0.269832434	1.46983	0	0	1.2
C-14	E3 -- Hanford Only	10,000	0.26584615	0.26584615	0	0	1.69728E-06	0.265846151	1.46585	0	0	1.2
C-14	E3 -- Lower Bound	10,000	0.265849217	0.265849217	0	0	1.69729E-06	0.265849232	1.46585	0	0	1.2
C-14	E3 -- Upper Bound	10,000	0.266159853	0.266159853	0	0	1.69891E-06	0.266159844	1.46616	0	0	1.2
C-14	No Action -- Hanford Only	10,000	0.162687826	0.162687826	0	0	2.50048E-06	0.162687835	1.36269	0	0	1.2
C-14	No Action -- Lower Bound	10,000	0.162784028	0.162784028	0	0	2.50107E-06	0.162784036	1.36278	0	0	1.2
I-129	A -- Hanford Only	2,500	0.11974949	0.11974949	0.078838274	0.038081593	1.07402E-06	0.119749488	0.11975	0.0788383	0.0380816	1.09543E-06
I-129	A -- Lower Bound	2,500	0.120316062	0.120316062	0.079211283	0.038261793	1.07992E-06	0.120316063	0.120316	0.0792113	0.0382618	1.10133E-06
I-129	A -- Upper Bound	2,500	0.130782178	0.130782178	0.086101755	0.041590093	1.12433E-06	0.130782177	0.130782	0.0861018	0.0415901	1.14574E-06
I-129	B -- Hanford Only	2,500	0.119800368	0.119800368	0.07887177	0.038097793	1.05129E-06	0.119800378	0.1198	0.0788718	0.0380978	1.07269E-06
I-129	B -- Lower Bound	2,500	0.120378129	0.120378129	0.079252145	0.038281493	1.05221E-06	0.120378138	0.120378	0.0792522	0.0382815	1.07362E-06
I-129	B -- Upper Bound	2,500	0.128094982	0.128094982	0.084332613	0.040735593	1.10064E-06	0.128094979	0.128095	0.0843326	0.0407356	1.12204E-06
I-129	C -- Hanford Only	2,500	0.11974949	0.11974949	0.078838274	0.038081593	1.07402E-06	0.119749488	0.11975	0.0788383	0.0380816	1.09543E-06
I-129	C -- Lower Bound	2,500	0.120316062	0.120316062	0.079211283	0.038261793	1.07992E-06	0.120316063	0.120316	0.0792113	0.0382618	1.10133E-06
I-129	C -- Upper Bound	2,500	0.104448373	0.104448373	0.068764631	0.033215793	1.12433E-06	0.104448374	0.104448	0.0687646	0.0332158	1.14574E-06
I-129	D1 -- Hanford Only	2,500	0.11974949	0.11974949	0.078838274	0.038081593	1.07402E-06	0.119749488	0.11975	0.0788383	0.0380816	1.09543E-06
I-129	D1 -- Lower Bound	2,500	0.120316062	0.120316062	0.079211283	0.038261793	1.07992E-06	0.120316063	0.120316	0.0792113	0.0382618	1.10133E-06
I-129	D1 -- Upper Bound	2,500	0.127864635	0.127864635	0.084180961	0.040662293	1.12433E-06	0.127864649	0.127865	0.084181	0.0406623	1.14574E-06
I-129	D2 -- Hanford Only	2,500	0.11974949	0.11974949	0.078838274	0.038081593	1.07402E-06	0.119749488	0.11975	0.0788383	0.0380816	1.09543E-06
I-129	D2 -- Lower Bound	2,500	0.120316062	0.120316062	0.079211283	0.038261793	1.07992E-06	0.120316063	0.120316	0.0792113	0.0382618	1.10133E-06
I-129	D2 -- Upper Bound	2,500	0.127864635	0.127864635	0.084180961	0.040662293	1.12433E-06	0.127864649	0.127865	0.084181	0.0406623	1.14574E-06

Table I.6. (contd)

Constituent	EIS Alternative Group and Waste Volume	Time Period (y)	Hanford Only Concentrations					Hanford Only plus Background Concentrations				
			Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil pCi/kg)	River Water (pCi/L)	Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil (pCi/kg)	River Water (pCi/L)
I-129	D3 -- Hanford Only	2,500	0.11974949	0.11974949	0.078838274	0.038081593	1.07402E-06	0.119749488	0.11975	0.0788383	0.0380816	1.09543E-06
I-129	D3 -- Lower Bound	2,500	0.120316062	0.120316062	0.079211283	0.038261793	1.07992E-06	0.120316063	0.120316	0.0792113	0.0382618	1.10133E-06
I-129	D3 -- Upper Bound	2,500	0.127864635	0.127864635	0.084180961	0.040662293	1.12433E-06	0.127864649	0.127865	0.084181	0.0406623	1.14574E-06
I-129	E1 -- Hanford Only	2,500	0.11974949	0.11974949	0.078838274	0.038081593	1.07402E-06	0.119749488	0.11975	0.0788383	0.0380816	1.09543E-06
I-129	E1 -- Lower Bound	2,500	0.120316062	0.120316062	0.079211283	0.038261793	1.07992E-06	0.120316063	0.120316	0.0792113	0.0382618	1.10133E-06
I-129	E1 -- Upper Bound	2,500	0.127864635	0.127864635	0.084180961	0.040662293	1.12433E-06	0.127864649	0.127865	0.084181	0.0406623	1.14574E-06
I-129	E2 -- Hanford Only	2,500	0.11974949	0.11974949	0.078838274	0.038081593	1.07402E-06	0.119749488	0.11975	0.0788383	0.0380816	1.09543E-06
I-129	E2 -- Lower Bound	2,500	0.120316062	0.120316062	0.079211283	0.038261793	1.07992E-06	0.120316063	0.120316	0.0792113	0.0382618	1.10133E-06
I-129	E2 -- Upper Bound	2,500	0.127864635	0.127864635	0.084180961	0.040662293	1.12433E-06	0.127864649	0.127865	0.084181	0.0406623	1.14574E-06
I-129	E3 -- Hanford Only	2,500	0.11974949	0.11974949	0.078838274	0.038081593	1.07402E-06	0.119749488	0.11975	0.0788383	0.0380816	1.09543E-06
I-129	E3 -- Lower Bound	2,500	0.120316062	0.120316062	0.079211283	0.038261793	1.07992E-06	0.120316063	0.120316	0.0792113	0.0382618	1.10133E-06
I-129	E3 -- Upper Bound	2,500	0.127864635	0.127864635	0.084180961	0.040662293	1.12433E-06	0.127864649	0.127865	0.084181	0.0406623	1.14574E-06
I-129	No Action -- Hanford Only	2,500	0.125311105	0.125311105	0.082499819	0.039853593	1.0798E-05	0.125311109	0.125311	0.0824998	0.0398536	1.08194E-05
I-129	No Action -- Lower Bound	2,500	0.126560891	0.126560891	0.083322628	0.040250993	1.08115E-05	0.126560887	0.126561	0.0833226	0.040251	1.08329E-05
Tc-99	A -- Hanford Only	2,500	27.15197489	27.151995	0	0	0.0003222	27.15197489	27.1819	0	0	0.0302272
Tc-99	A -- Lower Bound	2,500	27.39874461	27.398695	0	0	0.000325	27.39874461	27.4286	0	0	0.03023
Tc-99	A -- Upper Bound	2,500	29.93080273	29.930795	0	0	0.000345	29.93080273	29.9607	0	0	0.03025
Tc-99	B -- Hanford Only	2,500	28.00434551	28.004395	0	0	0.0003209	28.00434551	28.0343	0	0	0.0302259
Tc-99	B -- Lower Bound	2,500	27.91135856	27.911395	0	0	0.002927	27.91135856	27.9413	0	0	0.032832
Tc-99	B -- Upper Bound	2,500	30.31284024	30.312795	0	0	0.002949	30.31284024	30.3427	0	0	0.032854
Tc-99	C -- Hanford Only	2,500	27.15197489	27.151995	0	0	0.0001392	27.15197489	27.1819	0	0	0.0300442
Tc-99	C -- Lower Bound	2,500	27.39874461	27.398695	0	0	0.000142	27.39874461	27.4286	0	0	0.030047
Tc-99	C -- Upper Bound	2,500	27.68929441	27.689295	0	0	0.000159	27.68929441	27.7192	0	0	0.030064
Tc-99	D1 -- Hanford Only	2,500	23.21149495	23.211495	0	0	0.0003192	23.21149495	23.2414	0	0	0.0302242
Tc-99	D1 -- Lower Bound	2,500	23.43689509	23.436895	0	0	0.0003266	23.43689509	23.4668	0	0	0.0302316
Tc-99	D1 -- Upper Bound	2,500	25.71971436	25.719695	0	0	0.0003435	25.71971436	25.7496	0	0	0.0302485
Tc-99	D2 -- Hanford Only	2,500	38.78891164	38.788895	0	0	0.0003529	38.78891164	38.8188	0	0	0.0302579
Tc-99	D2 -- Lower Bound	2,500	39.1579924	39.157995	0	0	0.0003562	39.1579924	39.1879	0	0	0.0302612
Tc-99	D2 -- Upper Bound	2,500	41.44685661	41.446895	0	0	0.0003762	41.44685661	41.4768	0	0	0.0302812
Tc-99	D3 -- Hanford Only	2,500	26.1322235	26.132195	0	0	0.0003212	26.1322235	26.1621	0	0	0.0302262
Tc-99	D3 -- Lower Bound	2,500	26.37732699	26.377295	0	0	0.0003241	26.37732699	26.4072	0	0	0.0302291
Tc-99	D3 -- Upper Bound	2,500	28.66097581	28.660995	0	0	0.0003441	28.66097581	28.6909	0	0	0.0302491
Tc-99	E1 -- Hanford Only	2,500	38.78891164	38.788895	0	0	0.0003529	38.78891164	38.8188	0	0	0.0302579
Tc-99	E1 -- Lower Bound	2,500	39.1579924	39.157995	0	0	0.0003562	39.1579924	39.1879	0	0	0.0302612
Tc-99	E1 -- Upper Bound	2,500	41.44685661	41.446895	0	0	0.0003775	41.44685661	41.4768	0	0	0.0302825
Tc-99	E2 -- Hanford Only	2,500	23.21149495	23.211495	0	0	0.0003192	23.21149495	23.2414	0	0	0.0302242
Tc-99	E2 -- Lower Bound	2,500	23.43689509	23.436895	0	0	0.0003223	23.43689509	23.4668	0	0	0.0302273
Tc-99	E1 -- Upper Bound	2,500	25.71971436	25.719695	0	0	0.0003435	25.71971436	25.7496	0	0	0.0302485
Tc-99	E3 -- Hanford Only	2,500	26.16809347	26.168095	0	0	0.0003216	26.16809347	26.198	0	0	0.0302266
Tc-99	E3 -- Lower Bound	2,500	26.42107155	26.421095	0	0	0.0003246	26.42107155	26.451	0	0	0.0302296
Tc-99	E3 -- Upper Bound	2,500	28.48323888	28.483195	0	0	0.0003458	28.48323888	28.5131	0	0	0.0302508
Tc-99	No Action -- Hanford Only	2,500	26.47523623	26.475195	0	0	5.43E-05	26.47523623	26.5051	0	0	0.0299593
Tc-99	No Action -- Lower Bound	2,500	26.8241731	26.824195	0	0	5.76E-05	26.8241731	26.8541	0	0	0.0299626
U-233	A -- Hanford Only	10,000	0.019239124	0.0192391	0.0115435	0.00743482	8.71298E-07	0.019239124	0.0192391	0.0115435	0.00743482	8.71298E-07
U-233	A -- Lower Bound	10,000	0.019239124	0.0192391	0.0115435	0.00743482	8.71298E-07	0.019239124	0.0192391	0.0115435	0.00743482	8.71298E-07
U-233	A -- Upper Bound	10,000	0.019240732	0.0192407	0.0115444	0.00743544	8.71309E-07	0.019240732	0.0192407	0.0115444	0.00743544	8.71309E-07
U-233	B -- Hanford Only	10,000	0.020020185	0.0200202	0.0120121	0.00773664	8.71166E-07	0.020020185	0.0200202	0.0120121	0.00773664	8.71166E-07
U-233	B -- Lower Bound	10,000	0.020102212	0.0201022	0.0120613	0.00776986	4.55143E-06	0.020102212	0.0201022	0.0120613	0.00776986	4.55143E-06
U-233	B -- Upper Bound	10,000	0.021904117	0.0219041	0.0131425	0.00846809	9.2312E-06	0.021904117	0.0219041	0.0131425	0.00846809	9.2312E-06

Table I.6. (contd)

Constituent	EIS Alternative Group and Waste Volume	Time Period (y)	Hanford Concentrations					Hanford plus Background Concentrations				
			Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil (pCi/kg)	River Water (pCi/L)	Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil (pCi/kg)	River Water (pCi/L)
U-233	C -- Hanford Only	10,000	0.019239124	0.0192391	0.0115435	0.00743482	8.71298E-07	0.019239124	0.0192391	0.0115435	0.00743482	8.71298E-07
U-233	C -- Lower Bound	10,000	0.019239124	0.0192391	0.0115435	0.00743482	8.71298E-07	0.019239124	0.0192391	0.0115435	0.00743482	8.71298E-07
U-233	C -- Upper Bound	10,000	0.019240732	0.0192407	0.0115444	0.00743544	8.71298E-07	0.019240732	0.0192407	0.0115444	0.00743544	8.71298E-07
U-233	D1 -- Hanford Only	10,000	0.019277384	0.0192774	0.0115664	0.0074496	8.71744E-07	0.019277384	0.0192774	0.0115664	0.0074496	8.71744E-07
U-233	D1 -- Lower Bound	10,000	0.019284664	0.0192847	0.0115708	0.00745242	8.71829E-07	0.019284664	0.0192847	0.0115708	0.00745242	8.71829E-07
U-233	D1 -- Upper Bound	10,000	0.019234761	0.0192348	0.0115409	0.00743313	8.72232E-07	0.019234761	0.0192348	0.0115409	0.00743313	8.72232E-07
U-233	D2 -- Hanford Only	10,000	0.019300122	0.0193001	0.0115801	0.00745839	8.71405E-07	0.019300122	0.0193001	0.0115801	0.00745839	8.71405E-07
U-233	D2 -- Lower Bound	10,000	0.019310109	0.0193101	0.0115861	0.00746225	8.71448E-07	0.019310109	0.0193101	0.0115861	0.00746225	8.71448E-07
U-233	D2 -- Upper Bound	10,000	0.019311717	0.0193117	0.011587	0.00746287	8.71675E-07	0.019311717	0.0193117	0.011587	0.00746287	8.71675E-07
U-233	D3 -- Hanford Only	10,000	0.019217548	0.0192175	0.0115305	0.00742648	8.71047E-07	0.019217548	0.0192175	0.0115305	0.00742648	8.71047E-07
U-233	D3 -- Lower Bound	10,000	0.019217548	0.0192175	0.0115305	0.00742648	8.71047E-07	0.019217548	0.0192175	0.0115305	0.00742648	8.71047E-07
U-233	D3 -- Upper Bound	10,000	0.021744197	0.0217442	0.0130465	0.00840284	8.71057E-07	0.021744197	0.0217442	0.0130465	0.00840284	8.71057E-07
U-233	E1 -- Hanford Only	10,000	0.019314552	0.0193146	0.0115887	0.00746397	8.71317E-07	0.019314552	0.0193146	0.0115887	0.00746397	8.71317E-07
U-233	E1 -- Lower Bound	10,000	0.019330398	0.0193304	0.0115982	0.00747009	8.7136E-07	0.019330398	0.0193304	0.0115982	0.00747009	8.7136E-07
U-233	E1 -- Upper Bound	10,000	0.019405028	0.019405	0.011643	0.00749893	8.71587E-07	0.019405028	0.019405	0.011643	0.00749893	8.71587E-07
U-233	E2 -- Hanford Only	10,000	0.02250883	0.0225088	0.0135053	0.00869962	4.0334E-06	0.02250883	0.0225088	0.0135053	0.00869962	4.0334E-06
U-233	E2 -- Lower Bound	10,000	0.023094958	0.023095	0.013857	0.00892635	4.59661E-06	0.023094958	0.023095	0.013857	0.00892635	4.59661E-06
U-233	E2 -- Upper Bound	10,000	0.024828055	0.0248281	0.0148968	0.00959675	6.26212E-06	0.024828055	0.0248281	0.0148968	0.00959675	6.26212E-06
U-233	E3 -- Hanford Only	10,000	0.019218308	0.0192183	0.011531	0.00742678	8.71229E-07	0.019218308	0.0192183	0.011531	0.00742678	8.71229E-07
U-233	E3 -- Lower Bound	10,000	0.019218308	0.0192183	0.011531	0.00742678	8.71229E-07	0.019218308	0.0192183	0.011531	0.00742678	8.71229E-07
U-233	E3 -- Upper Bound	10,000	0.019219916	0.0192199	0.0115319	0.0074274	8.71239E-07	0.019219916	0.0192199	0.0115319	0.0074274	8.71239E-07
U-233	No Action -- Hanford Only	10,000	0.019314758	0.0193148	0.0115889	0.00746375	1.48031E-07	0.019314758	0.0193148	0.0115889	0.00746375	1.48031E-07
U-233	No Action -- Lower Bound	10,000	0.0193303	0.0193303	0.0115982	0.00746975	1.4804E-07	0.0193303	0.0193303	0.0115982	0.00746975	1.4804E-07
U-234	A -- Hanford Only	10,000	0.000817116	0.000817117	0.00049027	0.00031625	1.19975E-06	0.000817116	0.000826629	0.000495977	0.000320184	0.000010712
U-234	A -- Lower Bound	10,000	0.000817117	0.000817117	0.00049027	0.00031625	1.19975E-06	0.000817117	0.000826629	0.000495977	0.000320184	0.000010712
U-234	A -- Upper Bound	10,000	0.163744407	0.163744488	0.098246593	0.063275666	2.22165E-06	0.163744407	0.163754	0.0982523	0.0632796	1.17339E-05
U-234	B -- Hanford Only	10,000	0.437474418	0.437474488	0.262484293	0.169051066	1.24315E-06	0.437474418	0.437484	0.26249	0.169055	1.07554E-05
U-234	B -- Lower Bound	10,000	0.448669574	0.448669488	0.269201293	0.175305066	0.004661618	0.448669574	0.448679	0.269207	0.175309	0.00467113
U-234	B -- Upper Bound	10,000	0.621507956	0.621507488	0.372904293	0.244577066	0.010667488	0.621507956	0.621517	0.37291	0.244581	0.010677
U-234	C -- Hanford Only	10,000	0.000817116	0.000817117	0.00049027	0.00031625	1.19975E-06	0.000817116	0.000826629	0.000495977	0.000320184	0.000010712
U-234	C -- Lower Bound	10,000	0.000817117	0.000817117	0.00049027	0.00031625	1.19975E-06	0.000817117	0.000826629	0.000495977	0.000320184	0.000010712
U-234	C -- Upper Bound	10,000	0.163744407	0.163744488	0.098246593	0.063275266	1.19985E-06	0.163744407	0.163754	0.0982523	0.0632792	1.07121E-05
U-234	D1 -- Hanford Only	10,000	0.000887535	0.000887535	0.000532521	0.000343461	1.20065E-06	0.000887535	0.000897047	0.000538228	0.000347395	1.07129E-05
U-234	D1 -- Lower Bound	10,000	0.000899636	0.000899636	0.000539782	0.000348137	1.20075E-06	0.000899636	0.000909148	0.000545489	0.000352071	0.000010713
U-234	D1 -- Upper Bound	10,000	0.16373658	0.163736488	0.098241893	0.063272666	2.22375E-06	0.16373658	0.163746	0.0982476	0.0632766	0.000011736
U-234	D2 -- Hanford Only	10,000	0.000918869	0.000918869	0.000551322	0.000355569	1.20015E-06	0.000918869	0.000928381	0.000557029	0.000359503	1.07124E-05
U-234	D2 -- Lower Bound	10,000	0.000935462	0.000935462	0.000561278	0.000361981	1.20025E-06	0.000935462	0.000944974	0.000566985	0.000365915	1.07125E-05
U-234	D2 -- Upper Bound	10,000	0.163898492	0.163898488	0.098339093	0.063335266	2.22265E-06	0.163898492	0.163908	0.0983448	0.0633392	1.17349E-05
U-234	D3 -- Hanford Only	10,000	0.000805163	0.000805163	0.000483098	0.00031163	1.19965E-06	0.000805163	0.000814675	0.000488805	0.000315564	1.07119E-05
U-234	D3 -- Lower Bound	10,000	0.000805163	0.000805163	0.000483098	0.00031163	1.19965E-06	0.000805163	0.000814675	0.000488805	0.000315564	1.07119E-05
U-234	D3 -- Upper Bound	10,000	0.168912953	0.168912488	0.101347293	0.065272966	2.22145E-06	0.168912953	0.168922	0.101353	0.0652769	1.17337E-05
U-234	E1 -- Hanford Only	10,000	0.000965755	0.000965755	0.000579454	0.000373687	1.20015E-06	0.000965755	0.000975267	0.000585161	0.000377621	1.07124E-05
U-234	E1 -- Lower Bound	10,000	0.000992088	0.000992088	0.000595253	0.000383863	1.20015E-06	0.000992088	0.0010016	0.00060096	0.000387797	1.07124E-05
U-234	E1 -- Upper Bound	10,000	0.164112626	0.164112488	0.098467593	0.063417966	2.22265E-06	0.164112626	0.164122	0.0984733	0.0634219	1.17349E-05
U-234	E2 -- Hanford Only	10,000	0.006310399	0.006310398	0.003786243	0.002441176	6.48925E-06	0.006310399	0.00631991	0.00379195	0.00244511	1.60015E-05
U-234	E2 -- Lower Bound	10,000	0.00725084	0.007250838	0.004350503	0.002804956	7.39255E-06	0.00725084	0.00726035	0.00435621	0.00280889	1.69048E-05
U-234	E2 -- Upper Bound	10,000	0.175947854	0.175947488	0.105568293	0.068060566	0.000169494	0.175947854	0.175957	0.105574	0.0680645	0.000179006
U-234	E3 -- Hanford Only	10,000	0.000805575	0.000805575	0.000483345	0.00031179	1.19975E-06	0.000805575	0.000815087	0.000489052	0.000315724	0.000010712
U-234	E3 -- Lower Bound	10,000	0.000805575	0.000805575	0.000483345	0.00031179	1.19975E-06	0.000805575	0.000815087	0.000489052	0.000315724	0.000010712

Table I.6. (contd)

Constituent	EIS Alternative Group and Waste Volume	Time Period (y)	Hanford Concentrations: Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil (pCi/kg)	River Water (pCi/L)	Hanford plus Background Concentrations: Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil (pCi/kg)	River Water (pCi/L)
U-234	E3 -- Upper Bound	10,000	0.163727573	0.163727488	0.098236593	0.063269166	2.22155E-06	0.163727573	0.163737	0.0982423	0.0632731	1.17338E-05
U-234	No Action -- Hanford Only	10,000	0.063315922	0.063315888	0.037989593	0.025317566	0.002057138	0.063315922	0.0633254	0.0379953	0.0253215	0.00206665
U-234	No Action -- Lower Bound	10,000	0.065050382	0.065050388	0.039030193	0.025987766	0.002057138	0.065050382	0.0650599	0.0390359	0.0259917	0.00206665
U-235	A -- Hanford Only	10,000	3.24189E-05	3.242E-05	0.000019451	0.000012567	9.43958E-08	3.24189E-05	0.00127766	0.000766595	0.000527568	0.00124533
U-235	A -- Lower Bound	10,000	3.24189E-05	3.242E-05	0.000019451	0.000012567	9.43958E-08	3.24189E-05	0.00127766	0.000766595	0.000527568	0.00124533
U-235	A -- Upper Bound	10,000	0.007244668	0.00724467	0.004346796	0.002799569	1.3963E-07	0.007244668	0.00848991	0.00509394	0.00331457	0.00124538
U-235	B -- Hanford Only	10,000	0.012640731	0.01264076	0.007584436	0.004884719	9.56152E-08	0.012640731	0.013886	0.00833158	0.00539972	0.00124534
U-235	B -- Lower Bound	10,000	0.012982447	0.01298246	0.007789466	0.005072009	0.000133661	0.012982447	0.0142277	0.00853661	0.00558701	0.0013789
U-235	B -- Upper Bound	10,000	0.025609443	0.02560946	0.015365656	0.010021299	0.000302795	0.025609443	0.0268547	0.0161128	0.0105363	0.00154803
U-235	C -- Hanford Only	10,000	3.24189E-05	3.242E-05	0.000019451	0.000012567	9.43958E-08	3.24189E-05	0.00127766	0.000766595	0.000527568	0.00124533
U-235	C -- Lower Bound	10,000	3.24189E-05	3.242E-05	0.000019451	0.000012567	9.43958E-08	3.24189E-05	0.00127766	0.000766595	0.000527568	0.00124533
U-235	C -- Upper Bound	10,000	0.007244668	0.00724467	0.004346796	0.002799549	9.43981E-08	0.007244668	0.00848991	0.00509394	0.00331455	0.00124533
U-235	D1 -- Hanford Only	10,000	4.76617E-05	4.766E-05	0.000028597	0.000018457	9.45735E-08	4.76617E-05	0.0012929	0.000775741	0.000533458	0.00124533
U-235	D1 -- Lower Bound	10,000	5.01931E-05	5.019E-05	0.000030116	0.000019435	9.46029E-08	5.01931E-05	0.00129543	0.00077726	0.000534436	0.00124533
U-235	D1 -- Upper Bound	10,000	0.007244331	0.00724433	0.004346596	0.002799439	1.40001E-07	0.007244331	0.00848957	0.00509374	0.00331444	0.00124538
U-235	D2 -- Hanford Only	10,000	5.3649E-05	5.365E-05	0.000032189	0.000020771	9.44844E-08	5.3649E-05	0.00129889	0.000779333	0.000535772	0.00124533
U-235	D2 -- Lower Bound	10,000	5.71201E-05	5.712E-05	3.4272E-05	0.000022112	9.44993E-08	5.71201E-05	0.00130236	0.000781416	0.000537113	0.00124533
U-235	D2 -- Upper Bound	10,000	0.007271502	0.0072715	0.004362896	0.002809939	1.39823E-07	0.007271502	0.00851674	0.00511004	0.00332494	0.00124538
U-235	D3 -- Hanford Only	10,000	3.19318E-05	3.193E-05	1.9159E-05	1.2379E-05	9.43902E-08	3.19318E-05	0.00127717	0.000766303	0.00052738	0.00124533
U-235	D3 -- Lower Bound	10,000	3.19318E-05	3.193E-05	1.9159E-05	1.2379E-05	9.43902E-08	3.19318E-05	0.00127717	0.000766303	0.00052738	0.00124533
U-235	D3 -- Upper Bound	10,000	0.008184418	0.00818442	0.004910646	0.003162709	1.39623E-07	0.008184418	0.00942966	0.005765779	0.00367771	0.00124538
U-235	E1 -- Hanford Only	10,000	6.54069E-05	6.541E-05	3.9244E-05	0.000025314	9.44824E-08	6.54069E-05	0.00131065	0.000786388	0.000540315	0.00124533
U-235	E1 -- Lower Bound	10,000	7.09157E-05	7.092E-05	4.2549E-05	0.000027443	9.44974E-08	7.09157E-05	0.00131616	0.000789693	0.000542444	0.00124533
U-235	E1 -- Upper Bound	10,000	0.007313104	0.0073131	0.004387866	0.002826019	1.39821E-07	0.007313104	0.00855834	0.00513501	0.00334102	0.00124538
U-235	E2 -- Hanford Only	10,000	0.001176579	0.00117658	0.000705946	0.000455153	1.1942E-06	0.001176579	0.00242182	0.00145309	0.000970154	0.00124643
U-235	E2 -- Lower Bound	10,000	0.001379792	0.00137979	0.000827876	0.000533759	1.38946E-06	0.001379792	0.00262503	0.00157502	0.00104876	0.00124663
U-235	E2 -- Upper Bound	10,000	0.009362415	0.00936246	0.005617446	0.003621609	9.06002E-06	0.009362415	0.0106077	0.00636459	0.00413661	0.0012543
U-235	E3 -- Hanford Only	10,000	3.19489E-05	0.00003195	0.000019169	1.2385E-05	9.43942E-08	3.19489E-05	0.00127719	0.000766313	0.000527386	0.00124533
U-235	E3 -- Lower Bound	10,000	3.19489E-05	0.00003195	0.000019169	1.2385E-05	9.43942E-08	3.19489E-05	0.00127719	0.000766313	0.000527386	0.00124533
U-235	E3 -- Upper Bound	10,000	0.007243963	0.00724396	0.004346376	0.002799299	1.39627E-07	0.007243963	0.0084892	0.00509352	0.0033143	0.00124538
U-235	No Action -- Hanford Only	10,000	0.006186834	0.00618683	0.003712096	0.002588319	0.000477735	0.006186834	0.00743207	0.00445924	0.00310332	0.00172297
U-235	No Action -- Lower Bound	10,000	0.00624078	0.00624078	0.003744466	0.002609169	0.000477735	0.00624078	0.00748602	0.00449161	0.00312417	0.00172297
U-236	A -- Hanford Only	10,000	1.44967E-05	1.44967E-05	8.69801E-06	5.60296E-06	2.64836E-09	1.44967E-05	1.44967E-05	8.69801E-06	5.60296E-06	2.64836E-09
U-236	A -- Lower Bound	10,000	1.44967E-05	1.44967E-05	8.69802E-06	5.60297E-06	2.64836E-09	1.44967E-05	1.44967E-05	8.69802E-06	5.60297E-06	2.64836E-09
U-236	A -- Upper Bound	10,000	4.96879E-05	4.96879E-05	2.98127E-05	1.92018E-05	2.86907E-09	4.96879E-05	4.96879E-05	2.98127E-05	1.92018E-05	2.86907E-09
U-236	B -- Hanford Only	10,000	0.056462085	0.0564621	0.0338772	0.0218183	7.88492E-09	0.056462085	0.0564621	0.0338772	0.0218183	7.88492E-09
U-236	B -- Lower Bound	10,000	0.05789853	0.0578985	0.0347391	0.0226226	0.000602494	0.05789853	0.0578985	0.0347391	0.0226226	0.000602494
U-236	B -- Upper Bound	10,000	0.042325324	0.0423253	0.0253952	0.0169238	0.0013741	0.042325324	0.0423253	0.0253952	0.0169238	0.0013741
U-236	C -- Hanford Only	10,000	1.44967E-05	1.44967E-05	8.69801E-06	5.60296E-06	2.64837E-09	1.44967E-05	1.44967E-05	8.69801E-06	5.60296E-06	2.64837E-09
U-236	C -- Lower Bound	10,000	1.44967E-05	1.44967E-05	8.69802E-06	5.60297E-06	2.64837E-09	1.44967E-05	1.44967E-05	8.69802E-06	5.60297E-06	2.64837E-09
U-236	C -- Upper Bound	10,000	4.96879E-05	4.96879E-05	2.98127E-05	1.92017E-05	2.64837E-09	4.96879E-05	4.96879E-05	2.98127E-05	1.92017E-05	2.64837E-09
U-236	D1 -- Hanford Only	10,000	1.61736E-05	1.61736E-05	9.70415E-06	6.25096E-06	2.66792E-09	1.61736E-05	1.61736E-05	9.70415E-06	6.25096E-06	2.66792E-09
U-236	D1 -- Lower Bound	10,000	1.64687E-05	1.64687E-05	9.88122E-06	0.000006365	2.67135E-09	1.64687E-05	1.64687E-05	9.88122E-06	0.000006365	2.67135E-09
U-236	D1 -- Upper Bound	10,000	4.96515E-05	4.96515E-05	2.97909E-05	1.91877E-05	2.90786E-09	4.96515E-05	4.96515E-05	2.97909E-05	1.91877E-05	2.90786E-09
U-236	D2 -- Hanford Only	10,000	1.69772E-05	1.69772E-05	1.01863E-05	6.56151E-06	2.65594E-09	1.69772E-05	1.69772E-05	1.01863E-05	6.56151E-06	2.65594E-09
U-236	D2 -- Lower Bound	10,000	1.7382E-05	0.000017382	1.04292E-05	6.7179E-06	2.65768E-09	1.7382E-05	0.000017382	1.04292E-05	6.7179E-06	2.65768E-09
U-236	D2 -- Upper Bound	10,000	5.2613E-05	0.000052613	3.15678E-05	2.03321E-05	2.88712E-09	5.2613E-05	0.000052613	3.15678E-05	2.03321E-05	2.88712E-09
U-236	D3 -- Hanford	10,000	1.40597E-05	1.40597E-05	8.43584E-06	5.43411E-06	2.64329E-09	1.40597E-05	1.40597E-05	8.43584E-06	5.43411E-06	2.64329E-09
U-236	D3 -- Lower Bound	10,000	1.40597E-05	1.40597E-05	8.43584E-06	5.43411E-06	2.64329E-09	1.40597E-05	1.40597E-05	8.43584E-06	5.43411E-06	2.64329E-09

Table I.6. (contd)

Constituent	EIS Alternative Group and Waste Volume	Time Period (y)	Hanford Concentrations					Hanford plus Background Concentrations				
			Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil (pCi/kg)	River Water (pCi/L)	Well Water (pCi/L)	Pore Water (pCi/L)	Sediment (pCi/kg)	Soil (pCi/kg)	River Water (pCi/L)
U-236	D3 -- Upper Bound	10,000	0.000150066	0.000150066	9.00398E-05	5.79904E-05	2.864E-09	0.000150066	0.000150066	9.00398E-05	5.79904E-05	2.864E-09
U-236	E1 -- Hanford Only	10,000	1.79822E-05	1.79822E-05	1.07893E-05	6.94985E-06	2.65418E-09	1.79822E-05	1.79822E-05	1.07893E-05	6.94985E-06	2.65418E-09
U-236	E1 -- Lower Bound	10,000	1.86244E-05	1.86244E-05	1.11747E-05	7.19802E-06	2.65592E-09	1.86244E-05	1.86244E-05	1.11747E-05	7.19802E-06	2.65592E-09
U-236	E1 -- Upper Bound	10,000	5.67534E-05	5.67534E-05	0.000034052	2.19321E-05	2.88535E-09	5.67534E-05	5.67534E-05	0.000034052	2.19321E-05	2.88535E-09
U-236	E2 -- Hanford Only	10,000	0.000148445	0.000148445	8.90672E-05	5.74173E-05	1.31765E-07	0.000148445	0.000148445	8.90672E-05	5.74173E-05	1.31765E-07
U-236	E2 -- Lower Bound	10,000	0.000171572	0.000171572	0.000102943	6.63632E-05	1.5398E-07	0.000171572	0.000171572	0.000102943	6.63632E-05	1.5398E-07
U-236	E2 -- Upper Bound	10,000	0.000277881	0.000277881	0.000166729	0.000107486	2.56146E-07	0.000277881	0.000277881	0.000166729	0.000107486	2.56146E-07
U-236	E3 -- Hanford Only	10,000	1.4075E-05	0.000014075	8.44498E-06	0.00000544	2.64693E-09	1.4075E-05	0.000014075	8.44498E-06	0.00000544	2.64693E-09
U-236	E3 -- Lower Bound	10,000	1.4075E-05	0.000014075	8.44498E-06	0.00000544	2.64693E-09	1.4075E-05	0.000014075	8.44498E-06	0.00000544	2.64693E-09
U-236	E3 -- Upper Bound	10,000	4.92661E-05	4.92661E-05	2.95597E-05	1.90388E-05	2.86765E-09	4.92661E-05	4.92661E-05	2.95597E-05	1.90388E-05	2.86765E-09
U-236	No Action -- Hanford Only	10,000	0.005351044	0.00535104	0.00321063	0.00206862	2.05972E-06	0.005351044	0.00535104	0.00321063	0.00206862	2.05972E-06
U-236	No Action -- Lower Bound	10,000	0.005572981	0.00557298	0.00334379	0.00215439	2.05982E-06	0.005572981	0.00557298	0.00334379	0.00215439	2.05982E-06
U-238	A -- Hanford Only	10,000	0.000810499	0.000810499	0.000486	0.0003136	8.61969E-07	0.000810499	0.172506	0.103503	0.0713225	0.171696
U-238	A -- Lower Bound	10,000	0.000810499	0.000810499	0.000486	0.0003136	8.61969E-07	0.000810499	0.172506	0.103503	0.0713225	0.171696
U-238	A -- Upper Bound	10,000	0.169530834	0.169530826	0.101719	0.0655121	1.92015E-06	0.169530834	0.341226	0.204736	0.136521	0.171697
U-238	B -- Hanford Only	10,000	0.70126166	0.701261672	0.420757	0.2709851	9.27096E-07	0.70126166	0.872957	0.523774	0.341994	0.171696
U-238	B -- Lower Bound	10,000	0.719300064	0.719300074	0.43158	0.2810471	7.47675E-03	0.719300064	0.890995	0.534597	0.352056	0.179172
U-238	B -- Upper Bound	10,000	0.912198317	0.912198288	0.547319	0.3595301	1.70092E-02	0.912198317	1.08389	0.650336	0.430539	0.188704
U-238	C -- Hanford Only	10,000	0.000810499	0.000810499	0.000486	0.0003136	8.61969E-07	0.000810499	0.172506	0.103503	0.0713225	0.171696
U-238	C -- Lower Bound	10,000	0.000810499	0.000810499	0.000486	0.0003136	8.61969E-07	0.000810499	0.172506	0.103503	0.0713225	0.171696
U-238	C -- Upper Bound	10,000	0.169530834	0.169530826	0.101719	0.0655111	8.62022E-07	0.169530834	0.341226	0.204736	0.13652	0.171696
U-238	D1 -- Hanford Only	10,000	0.00098345	0.00098345	0.00059	0.0003804	8.63985E-07	0.00098345	0.172678	0.103607	0.0713893	0.171696
U-238	D1 -- Lower Bound	10,000	0.001012394	0.001012394	0.000607	0.0003916	8.64321E-07	0.001012394	0.172707	0.103624	0.0714005	0.171696
U-238	D1 -- Upper Bound	10,000	0.169523881	0.169523868	0.101714	0.0655091	1.92478E-06	0.169523881	0.341219	0.204731	0.136518	0.171697
U-238	D2 -- Hanford Only	10,000	0.00105326	0.00105326	0.000632	0.0004074	8.62946E-07	0.00105326	0.172748	0.103649	0.0714163	0.171696
U-238	D2 -- Lower Bound	10,000	0.001092949	0.001092949	0.000656	0.0004227	8.63117E-07	0.001092949	0.172788	0.103673	0.0714316	0.171696
U-238	D2 -- Upper Bound	10,000	0.169868924	0.169868923	0.101921	0.0656421	1.92253E-06	0.169868924	0.341564	0.204938	0.136651	0.171697
U-238	D3 -- Hanford Only	10,000	0.000800013	0.000800013	0.00048	0.0003095	8.61847E-07	0.000800013	0.172495	0.103497	0.0713184	0.171696
U-238	D3 -- Lower Bound	10,000	0.000800013	0.000800013	0.00048	0.0003095	8.61847E-07	0.000800013	0.172495	0.103497	0.0713184	0.171696
U-238	D3 -- Upper Bound	10,000	0.181192852	0.181192838	0.108716	0.0700181	1.92E-06	0.181192852	0.352888	0.211733	0.141027	0.171697
U-238	E1 -- Hanford Only	10,000	0.001182977	0.001182977	0.00071	0.0004575	8.62904E-07	0.001182977	0.172878	0.103727	0.0714664	0.171696
U-238	E1 -- Lower Bound	10,000	0.001245964	0.001245964	0.000748	0.0004819	8.63074E-07	0.001245964	0.172941	0.103765	0.0714908	0.171696
U-238	E1 -- Upper Bound	10,000	0.170376505	0.170376502	0.102226	0.0658381	1.92248E-06	0.170376505	0.342072	0.205243	0.136847	0.171697
U-238	E2 -- Hanford Only	10,000	0.013893758	0.013893757	0.008336	0.0053745	1.34427E-05	0.013893758	0.185589	0.111353	0.0763834	0.171708
U-238	E2 -- Lower Bound	10,000	0.01621504	0.016215039	0.009729	0.0062724	1.56731E-05	0.01621504	0.18791	0.112746	0.0772813	0.171711
U-238	E2 -- Upper Bound	10,000	0.196173591	0.196173579	0.117704	0.0758841	1.88596E-04	0.196173591	0.367869	0.220721	0.146893	0.171884
U-238	E3 -- Hanford Only	10,000	0.000800381	0.000800381	0.00048	0.0003097	8.61935E-07	0.000800381	0.172495	0.103497	0.0713186	0.171696
U-238	E3 -- Lower Bound	10,000	0.000800381	0.000800381	0.00048	0.0003097	8.61935E-07	0.000800381	0.172495	0.103497	0.0713186	0.171696
U-238	E3 -- Upper Bound	10,000	0.169515166	0.169515162	0.101709	0.0655051	1.92008E-06	0.169515166	0.34121	0.204726	0.136514	0.171697
U-238	No Action -- Hanford Only	10,000	0.290101165	0.29010116	0.174061	0.1209931	2.14981E-02	0.290101165	0.461796	0.277078	0.192002	0.193193
U-238	No Action -- Lower Bound	10,000	0.292909003	0.292908983	0.175745	0.1220781	2.14981E-02	0.292909003	0.464604	0.278762	0.193087	0.193193

Table I.7. Hanford and Hanford Plus Background Total Uranium Concentrations in Well Water, Pore Water, Sediment, Soil, and River Water for Each Time Period and Alternative Group. Values were calculated based on the assumptions presented in Sections I.3.1 and I.3.2.

EIS Alternative Group and Waste Volume	Time Period (y)	Hanford Concentrations					Hanford plus Background Concentrations				
		Well Water (ug/L)	Pore Water (ug/L)	Sediment (ug/kg)	Soil (ug/kg)	River Water (ug/L)	Well Water (ug/L)	Pore Water (ug/L)	Sediment (ug/kg)	Soil (ug/kg)	River Water (ug/L)
A – Hanford Only	10,000	0.002426657	0.002426657	0.001455994	0.000939	2.60629E-06	0.002426657	0.513391	0.308034	0.212261	0.510967
A -- Lower Bound	10,000	0.002426657	0.002426657	0.001455994	0.000939	2.60629E-06	0.002426658	0.513391	0.308034	0.212261	0.510967
A -- Upper Bound	10,000	0.507332782	0.507332782	0.304399669	0.196048	5.77296E-06	0.5073328	1.0183	0.610978	0.40737	0.51097
B -- Hanford Only	10,000	2.091388031	2.091388031	1.254832818	0.808168	2.80054E-06	2.091388069	2.60235	1.56141	1.01949	0.510967
B -- Lower Bound	10,000	2.145191708	2.145191708	1.287115025	0.838178	0.022297551	2.145191729	2.65616	1.59369	1.0495	0.533262
B -- Upper Bound	10,000	2.72423406	2.72423406	1.634540436	1.073688	0.05072523	2.724234264	3.2352	1.94112	1.28501	0.561689
C -- Hanford Only	10,000	0.002426657	0.002426657	0.001455994	0.000939	2.60629E-06	0.002426657	0.513391	0.308034	0.212261	0.510967
C -- Lower Bound	10,000	0.002426657	0.002426657	0.001455994	0.000939	2.60629E-06	0.002426658	0.513391	0.308034	0.212261	0.510967
C -- Upper Bound	10,000	0.507332782	0.507332782	0.304399669	0.196047	2.60645E-06	0.5073328	1.0183	0.610978	0.407369	0.510967
D1 -- Hanford Only	10,000	0.002947869	0.002947869	0.001768721	0.001141	2.61237E-06	0.002947869	0.513912	0.308347	0.212463	0.510967
D1 -- Lower Bound	10,000	0.003035085	0.003035085	0.001821051	0.001174	2.61338E-06	0.003035084	0.513999	0.308399	0.212496	0.510967
D1 -- Upper Bound	10,000	0.507311939	0.507311939	0.304387164	0.19604	5.7869E-06	0.507311938	1.01828	0.610966	0.407362	0.51097
D2 -- Hanford Only	10,000	0.003158176	0.003158176	0.001894906	0.001222	2.60924E-06	0.003158176	0.514122	0.308473	0.212544	0.510967
D2 -- Lower Bound	10,000	0.003277771	0.003277771	0.001966662	0.001268	2.60975E-06	0.00327777	0.514242	0.308545	0.21259	0.510967
D2 -- Upper Bound	10,000	0.508350307	0.508350307	0.305010184	0.196442	5.78012E-06	0.508350297	1.01931	0.611589	0.407764	0.51097
D3 -- Hanford Only	10,000	0.002395252	0.002395252	0.001437151	0.000927	2.60593E-06	0.002395252	0.513359	0.308016	0.212249	0.510967
D3 -- Lower Bound	10,000	0.002395252	0.002395252	0.001437151	0.000927	2.60593E-06	0.002395252	0.513359	0.308016	0.212249	0.510967
D3 -- Upper Bound	10,000	0.542436875	0.542436875	0.325462125	0.209613	5.7725E-06	0.542436851	1.0534	0.632041	0.420935	0.51097
E1 -- Hanford Only	10,000	0.003549238	0.003549238	0.002129543	0.001373	2.60911E-06	0.003549238	0.514513	0.308708	0.212695	0.510967
E1 -- Lower Bound	10,000	0.003739038	0.003739038	0.002243423	0.001446	2.60962E-06	0.003739038	0.514703	0.308822	0.212768	0.510967
E1 -- Upper Bound	10,000	0.509878497	0.509878497	0.305927098	0.197032	5.77999E-06	0.509878475	1.02084	0.612505	0.408354	0.51097
E2 -- Hanford Only	10,000	0.041850761	0.041850761	0.025110456	0.016189	4.05159E-05	0.041850761	0.552815	0.331689	0.227511	0.511005
E2 -- Lower Bound	10,000	0.048845622	0.048845622	0.029307373	0.018895	4.72369E-05	0.048845624	0.55981	0.335886	0.230217	0.511011
E2 -- Upper Bound	10,000	0.587517291	0.587517291	0.352510375	0.227265	0.000564848	0.58751732	1.09848	0.659089	0.438587	0.511529
E3 -- Hanford Only	10,000	0.002396352	0.002396352	0.001437811	0.000928	2.60619E-06	0.002396352	0.51336	0.308016	0.21225	0.510967
E3 -- Lower Bound	10,000	0.002396352	0.002396352	0.001437811	0.000928	2.60619E-06	0.002396352	0.51336	0.308016	0.21225	0.510967
E3 -- Upper Bound	10,000	0.507285879	0.507285879	0.304371527	0.19603	5.77277E-06	0.507285904	1.01825	0.61095	0.407352	0.51097
No Action -- Hanford Only	10,000	0.87369709	0.87369709	0.524218254	0.364139	0.064127245	0.873697104	1.38466	0.830797	0.575461	0.575091
No Action -- Lower Bound	10,000	0.87369709	0.87369709	0.524218254	0.364139	0.064127245	0.873697104	1.38466	0.830797	0.575461	0.575091

The ECEM was run deterministically (single calculation using a single value for each input parameter—radionuclide concentration, partition coefficient, species uptake rates, and so on). Model output consisted of estimated equilibrium exposures for receptors (Table I.8) potentially affected by the (1) combined radiological toxicity of individual radionuclides (see Section I.3.4) and (2) chemical toxicity of total uranium (Labrot et al. 1999; Domingo 2001) (see Section I.3.5).

Table I.8. Ecological Contaminant Exposure Model Receptors

Common Name	Scientific Name
Terrestrial Animals	
American coot	*Fulica americana*
American kestrel	*Falco sparverius*
American white pelican	*Pelecanus erythrorhynchos*
Beaver	*Castor canadensis*
bald eagle	*Haliaeetus leucocephalus*
bufflehead	*Bucephala albeola*
California quail	*Callipepla californica*
Canada goose	*Branta canadensis*
cliff swallow	*Petrochelidon pyrrhonota*
Common snipe	*Gallinago gallinago*
Coyote	*Canis latrans*
Forster's tern	*Sterna forsteri*
great blue heron	*Ardea herodias*
harvest mouse	*Reithrodontomys megalotis*
lizards (generic)[a]	
Mallard	*Anas platyrhynchos*
mule deer	*Odocoileus hemionus*
Muskrat	*Ondatra zibethica*
Northern harrier	*Circus cyaneus*
Raccoon	*Procyon lotor*
Terrestrial arthropods (generic)	
Western aquatic garter snake	*Thamnophis elegans*
Weasel	*Mustela* spp.
Woodhouse's toad (adult)	*Bufo woodhousei*
Terrestrial Plants	
black cottonwood	*Populus trichocarpa*
Columbia yellowcress	*Rorippa columbiae*
dense sedge	*Carex densa*
fern (generic)	
fungi (generic)	
Mulberry	*Morus alba*
reed canarygrass	*Phalaris arundinacea*
Rushes	*Juncus* spp.
Tule	*Scirpus* spp.

(a) generic = not specific to a species or genus. Thus, none provided under “scientific name”.

Table I.8. (contd)

Aquatic Animals	
carp	*Cyprinus carpio*
channel catfish	*Ictalurus punctatus*
clams (generic)	
Columbia pebblesnail	*Flumicola columbiana*
crayfish (generic)	
water flea	*Daphnia magna*
fresh-water shrimp	*Hyallela* spp.
largescale/mountain sucker	*Catostomus macrocheilus*/*C. platyrhynchus*
mayfly (generic)	
mountain whitefish	*Prosopium williamsoni*
mussels (generic)	
Pacific lamprey (juvenile)	*Entosphenus tridentatus*
rainbow trout (adult)	*Salmo gairdneri*
rainbow trout (eggs)	*Salmo gairdneri*
rainbow trout (juvenile)	*Salmo gairdneri*
salmon (generic) (adult)	*Oncorhynchus* spp.
salmon (generic) (eggs)	*Oncorhynchus* spp.
salmon (generic) (juvenile)	"
smallmouth bass	*Micropterus dolomieui*
Woodhouse's toad (tadpole)	*Bufo woodhousei*
white sturgeon	*Acipenser transmontanus*
Aquatic Plants	
periphyton (generic)	
phytoplankton (generic)	
water milfoil	*Myriophyllum* spp.

I.3.4 Combined Radiological Toxicity

Estimated equilibrium exposures for terrestrial and aquatic animal and plant receptors consisted of total radiological dose (rad/day). Risk is assessed via calculation of environmental hazard quotients (EHQs). The EHQ, or level of risk, is indicated by the ratio of the estimated exposure to a measurement (effect) endpoint such as a radiological dose limit or standard.

Radiological risk EHQs are calculated by dividing the estimated total radiological dose by the applicable DOE dose limit or standard. These dose limits and standards are 1 rad/day for native aquatic animals (DOE 1993), 0.1 rad/day for terrestrial animals, and 1 rad/day for aquatic and terrestrial plants (DOE 2002). An EHQ greater than 1 indicates a potential risk of radiotoxic effects.

Environmental hazard quotients based on total dose from all radiological constituents are provided for the Hanford and Hanford plus background exposure scenarios for the one receptor in Table I.8 that was at maximal risk in each alternative group and time period. These receptors were the mayfly for all alternative groups in the 0- to 2500-year time period (Figure I.8) and Woodhouse's toad tadpole for all alternative groups in the 0- to 10,000-year time period (Figure I.9).

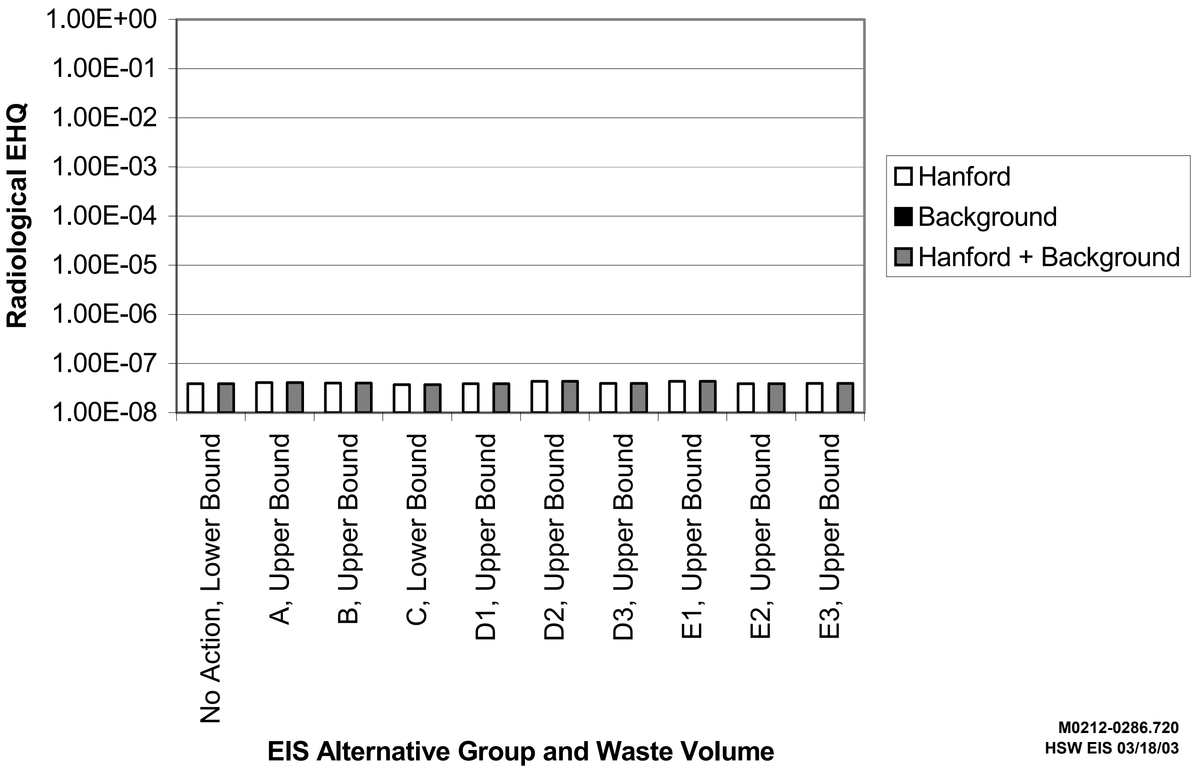

Figure I.8. Mayfly Radiological EHQs for Each Alternative Group in the 0- to 2500-Year Time Period for Background Compared to the Hanford and Hanford Plus Background Scenarios

Results are provided for only those waste volumes that yielded maximal risk (i.e., Lower Bound waste volumes for the No Action Alternative and Upper Bound waste volumes for Alternative Groups A, B, D_1, D_2, D_3, E_1, E_2, and E_3 for the 0- to 2500-year and the 2500- to 10,000-year time periods, as well as Lower and Upper Bound waste volumes for Alternative Group C for the 0- to 2500-year and 2500- to 10,000-year time periods, respectively).

The discussion below covers three points of interest: (1) Hanford's contribution to risk relative to the background contribution, (2) risk as a discriminator among the alternative groups, and (3) the magnitude of risk under each alternative group relative to a minimal level of concern (EHQ of 1).

Mayfly EHQs for the Hanford scenario are much larger than for background (Figure I.8), indicative of miniscule background concentrations of technetium-99 and iodine-129. Mayfly EHQs for both the Hanford and Hanford plus background scenarios were at least seven orders of magnitude below the minimal level of concern (EHQ of 1) (Figure I.8). Consequently, there is essentially no risk of adverse radiological impacts under any of the alternative groups for the 0- to 2500-year time period. Further,

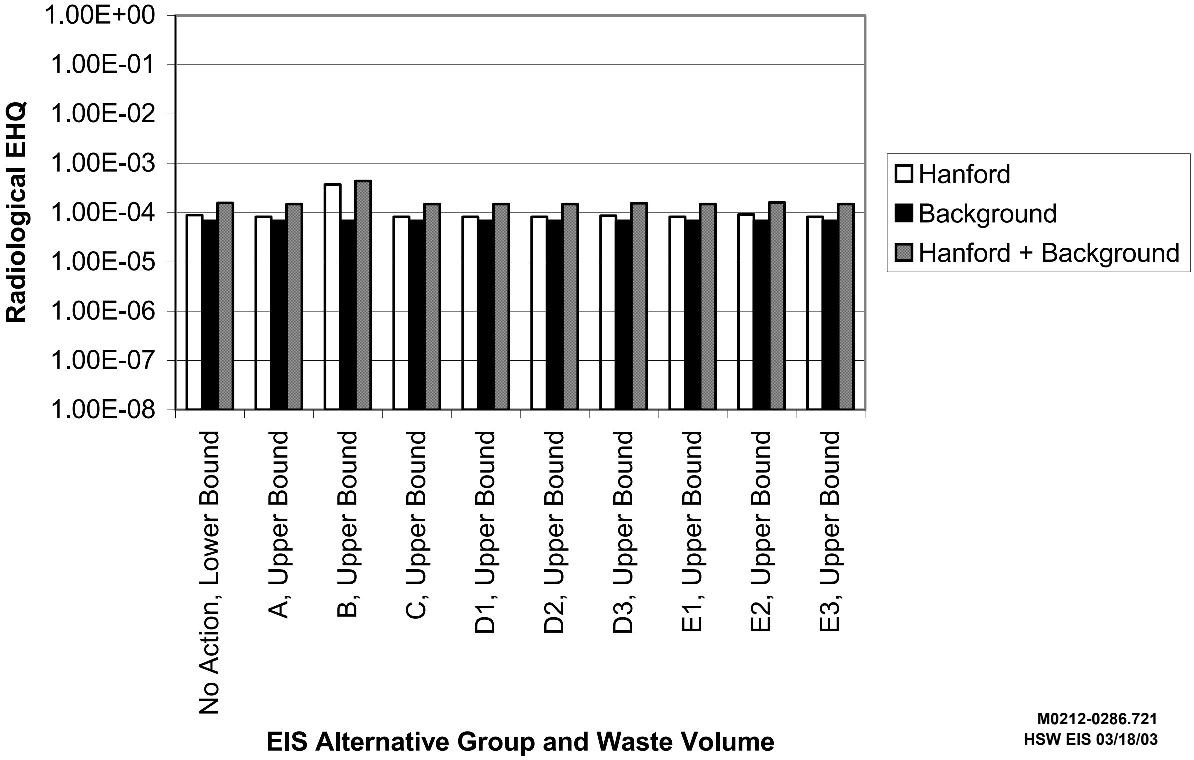

Figure I.9. Woodhouse's Toad Tadpole Radiological EHQs for Each Alternative Group in the 2500- to 10,000-Year Time Period for Background Compared to the Hanford and Hanford Plus Background Scenarios

radiological risk does not appear to be an important discriminator among the alternative groups in the0- to 2500-year time period because the mayfly EHQs were essentially the same for all the alternative groups (Figure I.8).

Woodhouse's toad tadpole EHQs for the Hanford scenario are slightly larger than for background under the Alternative Groups A, C, D_1, D_2, D_3, E_1, E_2, and E_3 (Figure I.9). Woodhouse's toad tadpole EHQs for the Hanford scenario are slightly higher relative to those for background for the No Action Alternative (Figure I.9) and substantially higher for Alternative Group B (Figure I.9). This is indicative of uranium levels elevated above background in all the alternative groups, particularly in Alternative Group B. Nonetheless, Woodhouse's toad tadpole EHQs for both the Hanford and Hanford plus background scenarios were at least three orders of magnitude below the minimal level of concern (EHQ of 1) (Figure I.9). Consequently, there is essentially no risk of adverse radiological impacts under any of the alternative groups for the 2500- to 10,000-year time period. Further, except for Alternative Groups A and B, radiological risk does not appear to be an important discriminator among the other alternative groups in the 2500- to 10,000-year time period because the Woodhouse's toad tadpole EHQs were essentially the same for these other alternative groups (Figure I.9).

I.3.5 Chemical Toxicity of Total Uranium

Terrestrial Receptors. Estimated equilibrium exposures for terrestrial receptors consisted of absorbed daily dose (µg/kg/day). Chemical toxicity EHQs for terrestrial animal receptors were calculated by dividing the estimated absorbed daily dose by the lowest dose known to produce a clinically toxic response in any member of a population (i.e., the lowest observed effects level or LOEL). The LOEL, based on chronic exposure, was selected because it was deemed to be most representative of effects that might occur during a long-term contaminant release.

Few data are available for assessing the toxic effects of non-pesticide chemicals on wildlife (Suter 1993). Consequently, it is generally necessary to use toxicity data for domestic animals that differ taxonomically (often widely so) from the species of interest. Also, the endpoint (e.g., LOEL) of a toxicity test may not apply to the exposure conditions of interest (e.g., mortality endpoint, such as an LD_{50} [median lethal dose, typically based on a 96-hour test] used to assess risk of lowest adverse effects to terrestrial animals under chronic exposure conditions). Such situations often require extrapolation of toxicity data across taxa and endpoints using uncertainty factors.

The chemical toxicity data used in calculating EHQs for terrestrial animal exposure to total uranium were as follows. Only two suitable uranium toxicity values were available. A LOEL of 6.13 mg/kg/day based on toxicity to mice (*Mus* spp.) (Opresko et al. 1995) was used. This value falls well within the range of doses known to cause reproductive and developmental effects in mice and rats (Domingo 2001). The mouse LOEL was extrapolated for use with all other terrestrial animal receptors by dividing it by an uncertainty factor of 10 (0.613 mg/kg/day). This extrapolation between taxa is consistent with DOE (1998).

In addition, a no observed adverse effects level (NOAEL) of 16 mg/kg/day, based on toxicity to black ducks (*Anas rubripes*) (Opresko et al. 1995) was used. The black duck NOAEL was multiplied by a factor of 10 to derive a LOEL (160 mg/kg/day) for use with all other terrestrial animal receptors. This extrapolation between endpoints is based on Dourson and Stara (1983) and is consistent with DOE (1998).

Because neither the derived black duck nor the derived mouse LOEL was considered more reliable, the former was used to calculate low and the latter high EHQs for all terrestrial animal receptors.

Low and high EHQs for total uranium, based on the derived black duck and mouse LOELs, respectively, are provided for the Hanford scenario and background (Figure I.10) and the Hanford plus background scenario (Figure I.11) for the one terrestrial animal receptor in Table I.8 that is at maximal risk in each alternative group in the 2500- to10,000-year time period—the American coot. Results are provided only for those waste volumes that yielded maximal risk (i.e., Hanford Only and Lower Bound waste volumes for the No Action Alternative and the Upper Bound waste volume for all other alternative groups).

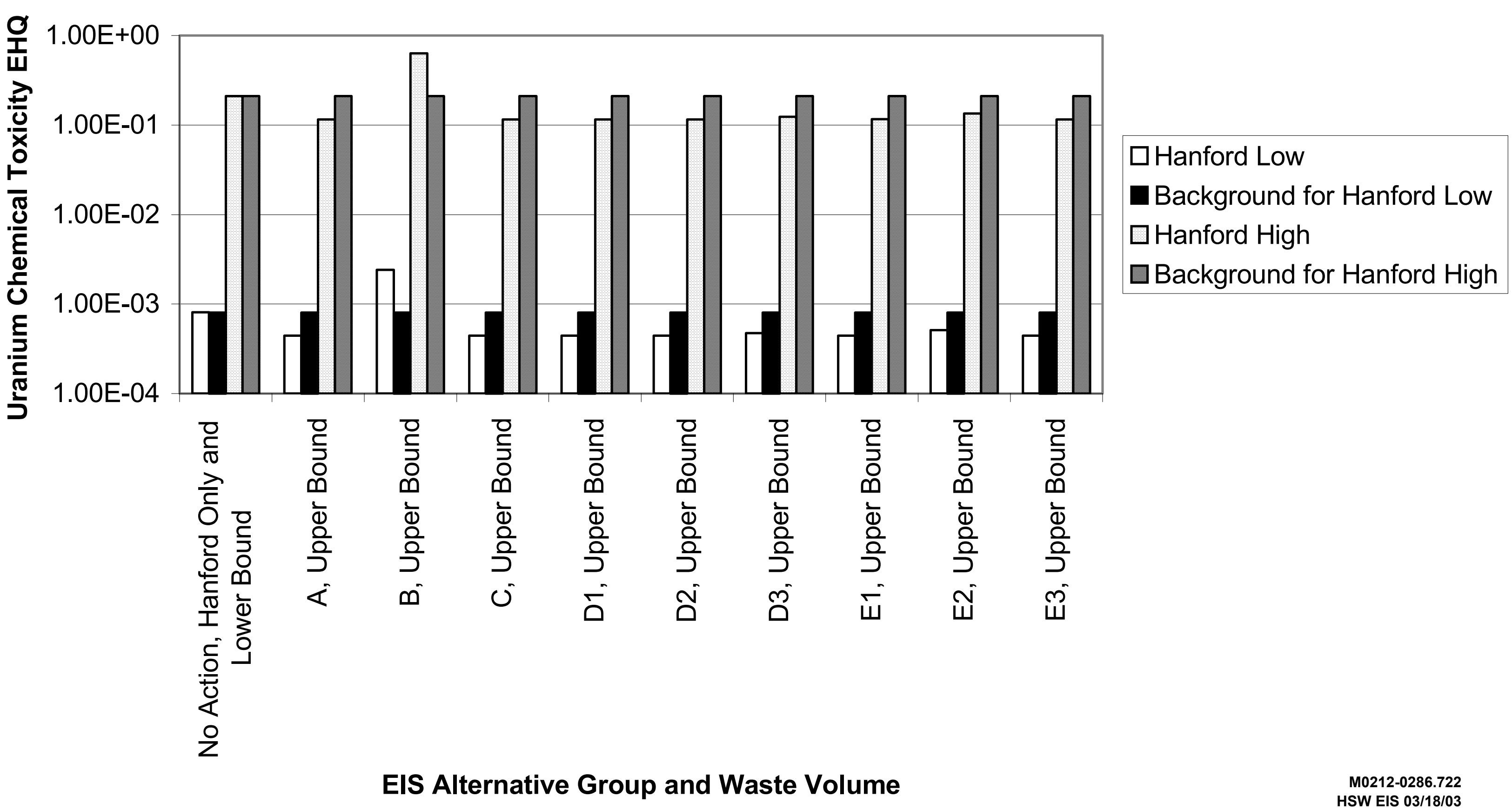

Figure I.10. American Coot Low and High Uranium Chemical Toxicity EHQs for Each Alternative Group in the 2500- to 10,000-Year Time Period for Background and the Hanford Scenario

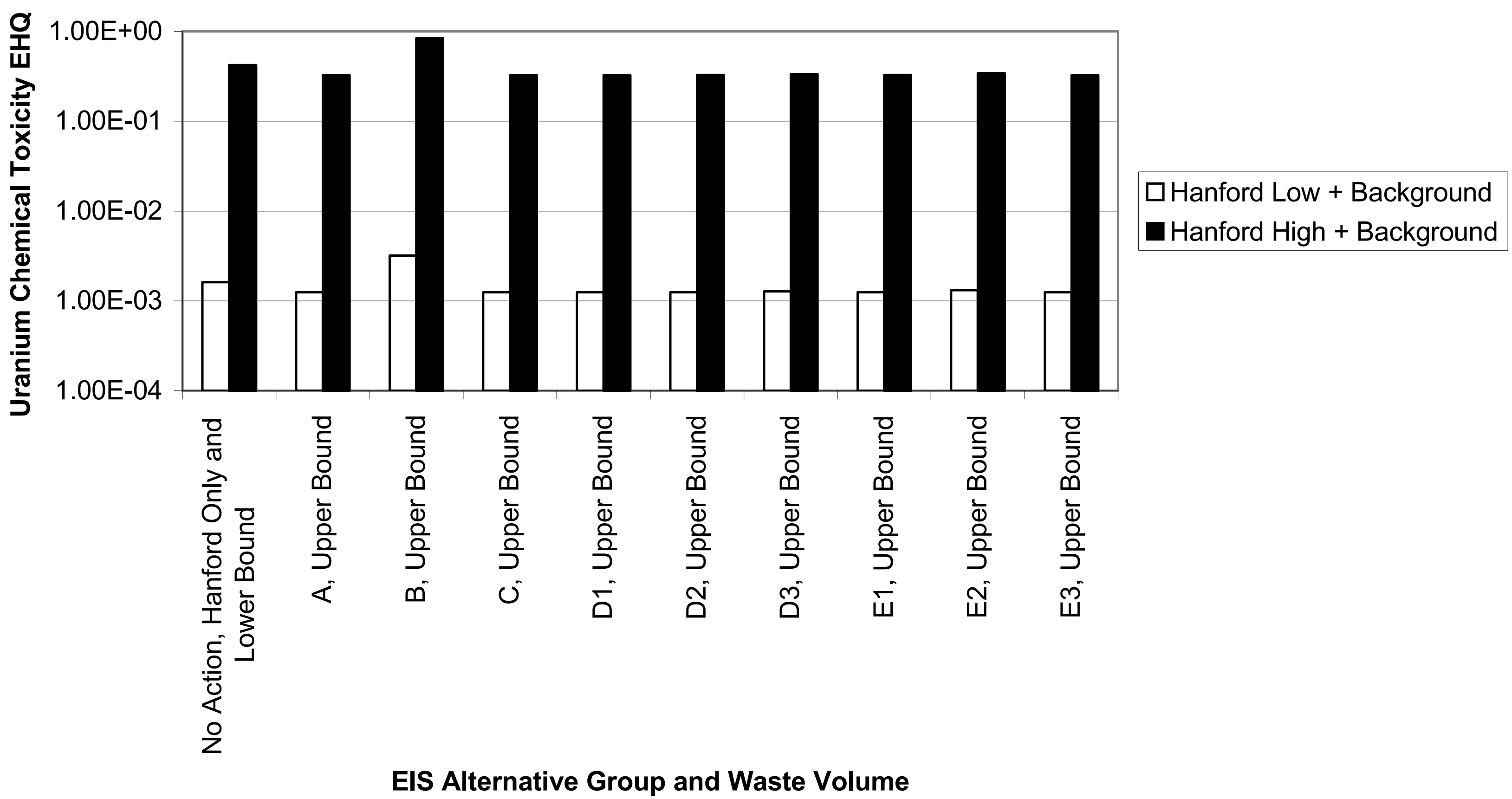

Figure I.11. American Coot Low and High Uranium Chemical Toxicity EHQs for Each Alternative Group in the 2500- to 10,000-Year Time Period for the Hanford Plus Background Scenario

The low and high coot EHQs for the Hanford scenario are less than for background under Alternative Groups A, C, D_1, D_2, D_3, E_1, E_2, and E_3 (Figure I.10). Coot EHQs for the Hanford scenario are equal to background for the No Action Alternative (Figure I.10) and substantially higher for Alternative Group B (Figure I.10), indicative of uranium levels elevated above background in Alternative Group B.

The high coot EHQs were approximately two to three orders of magnitude greater than the low EHQs (Figure I.10). Neither the low nor high coot EHQs exceeded the minimal level of concern (EHQ of 1) for either the Hanford (Figure I.10) or Hanford plus background (Figure I.11) scenarios. Because the entire range of coot EHQs was below an EHQ of 1 for both scenarios (Figures I.10 and I.11), only a negligible risk of uranium chemical toxicity to terrestrial receptors exists under all the alternative groups.

Except for Alternative Groups A and B, uranium chemical toxicity risk to terrestrial receptors does not appear to be an important discriminator among the other alternative groups because coot EHQs were essentially the same for these other alternative groups (Figure I.10).

Aquatic Receptors. Estimated equilibrium exposures for aquatic receptors are tissue concentrations expressed in terms of micrograms per kilogram (µg/kg). One way of calculating chemical toxicity EHQs for aquatic animal receptors is by dividing the estimated tissue concentration by the lowest tissue concentration known to produce a clinically toxic response (i.e., the lowest observed effects concentration, or LOEC), where such concentrations are available. The LOEC, based on chronic exposure, was selected because it was deemed to be most representative of effects that might occur during a long-term contaminant release.

LOECs or other tissue-concentration–based toxicity data were unavailable for aquatic animal receptors, so water-concentration–based toxicity data were used. EHQs thus were calculated by comparing the equivalent water concentration for the receptor with the lowest water concentration known to produce a clinically toxic response.

The equivalent water concentration in micrograms per liter (µg/L) is derived by dividing the receptor's estimated tissue concentration (µg/kg) by the bioconcentration factor (BCF) in liters per kilogram (L/kg). The BCF is the ratio of the tissue concentration of an aquatic organism to the water concentration where uptake is to limited to water alone, usually derived in an experimental setting. Thus, the equivalent water concentration is the water concentration that would result in the receptor's estimated tissue concentration via gill/respiratory uptake and dermal uptake alone (i.e., excluding uptake from foods, ingestion of sediment, and dermal uptake from sediment). The ratio of an equivalent water concentration to a water-concentration-based toxicity benchmark is equivalent to the ratio of a tissue concentration to a tissue-concentration-based toxicity benchmark such as a LOEC.

The BCF values used in deriving the equivalent water concentrations were those reported in conjunction with the aquatic toxicity data described below (i.e., 8.87E-03 for the teleost fish [of or belonging to a large group of fishes with bony skeletons] [*Brachydanio rerio*] and 55.67E-03 for the bivalve mollusk [*Corbicula fluminea*] [Labrot et al. 1999]). The teleost fish BCF was used to calculate equivalent water concentrations for fish, lamprey, and the Woodhouse's toad tadpole. The *Corbicula* BCF was used to calculate equivalent water concentrations for crayfish, mayfly, clams, mussels, and the Columbia pebble snail. In addition, more conservative BCFs from the literature (i.e., 50, the upper end of a range of BCFs [2 to 50] for generic fish, and 1000, the upper end of a range of BCFs [100 to 1000] for generic aquatic invertebrates [Fellows et al. 1998]) were similarly used. Because neither the generic nor species-specific BCFs were considered more reliable, the former were used to calculate low EHQs and the latter high EHQs.

As is the case with toxicity data for terrestrial receptors, it is frequently necessary to extrapolate aquatic toxicity data across taxa and endpoints using uncertainty factors. The chemical toxicity data used in calculating EHQs for aquatic animal exposure to total uranium were as follows. Only two suitable uranium values were available. Because LOECs and tissue-concentration-based toxicity data were lacking for uranium, a uranium 96-hour LC_{50} (median lethal concentration) (3.05 mg/L) for the teleost fish (Labrot et al. 1999) was used. This value was divided by 10 to yield a LOEC (0.305 mg/L). The derived teleost fish LOEC was used to calculate EHQs for fish, lamprey, and the Woodhouse's toad tadpole. A uranium 96-hour LC_{50} (1,872.08 mg/L) for the bivalve mollusk (Labrot et al. 1999) was divided by 10 to yield a LOEC (187.208 mg/L). The derived *Corbicula* LOEC was used to calculate EHQs for crayfish, mayfly, clams, mussels, and the Columbia pebble snail. The above extrapolations from acute to chronic toxicity values are based on Dourson and Stara (1983) and are consistent with DOE (1998).

Low and high EHQs for total uranium, based on the generic and Labrot et al. (1999) BCFs, respectively, are provided for the Hanford scenario and background (Figure I.12) and the Hanford plus background scenario (Figure I.13) for the one aquatic animal receptor in Table I.8 that is at maximal risk in each alternative group in the 2500- to 10,000-year time period—Woodhouse's toad tadpole. Results are provided for only those waste volumes that yielded maximal risk (i.e., Hanford Only and Lower Bound waste volumes for the No Action Alternative and the Upper Bound waste volume for all other alternative groups).

The high and low Woodhouse's toad tadpole EHQs for the Hanford scenario are less than for background under Alternative Groups A, C, D_1, D_2, D_3, E_1, E_2, and E_3 (Figure I.12). Tadpole EHQs for the Hanford scenario are equal to background for the No Action Alternative (Figure I.12) and substantially higher than background for Alternative Group B (Figure I.12), indicative of uranium levels elevated above background in Alternative Group B.

The high Woodhouse's toad tadpole EHQs were approximately three to four orders of magnitude greater than the low EHQs (Figure I.12). The low and high EHQs were below or well above and EHQ of one, respectively, for the Hanford (Figure I.12) and Hanford plus background scenarios (Figure I.13) for all the alternative groups. Based on the range of the EHQs alone, it is inconclusive whether or not there would be a non-discountable uranium chemical toxicity risk to this receptor. Further, it is important to note that both the low and high tadpole EHQs are based on uptake parameters (BCFs) and a toxicity benchmark from fish, which have questionable applicability when evaluating risk in toad tadpoles. Consequently, the EHQs of fish receptors at maximal risk should be examined as well.

The carp had the next highest EHQs behind Woodhouse's toad tadpole. Because largescale/mountain sucker and smallmouth bass EHQs differed from those of the carp by no more than 0.01 in any alternative group and scenario, the three species are considered together.

Low and high EHQs for total uranium, based on the generic and Labrot et al. (1999) BCFs, respectively, are provided for the Hanford scenario and background (Figure I.14) and the Hanford plus background scenario (Figure I.15) for the carp (and largescale/mountain sucker and smallmouth bass) in each alternative group in the 2500- to 10,000-year time period. Results are provided for only those waste volumes that yielded maximal risk (i.e., Hanford Only and Lower Bound waste volumes for the No Action Alternative and the Upper Bound waste volume for all other alternative groups).

The high carp (and largescale/mountain sucker and smallmouth bass) EHQs were approximately three to four orders of magnitude greater than the low EHQs (Figure I.14). Neither the high nor the low carp EHQs exceeded 1 for the Hanford (Figure I.14), or the Hanford plus background (Figure I.15) scenarios, except for Alternative Group B, in which the high EHQ was just slightly above 1 (Figures I.14 and I.15). Consequently, only a negligible risk of uranium chemical toxicity to these fish receptors exists under all the alternative groups, except Alternative Group B, because the entire range of EHQs for these three species falls below 1. There may be a slight risk of chronic uranium chemical toxicity to these fish receptors under Alternative Group B, although this is unlikely for the following reasons. First, the groundwater modeling of contaminants in the hypothetical well along the river and in the river was conservative (see Appendix G). Second, simultaneous exposure to maximum contaminant concentrations that do not always occur concurrently in time and space was assumed for this risk assessment (see Section I.3.1).

Carp (and largescale/mountain sucker and smallmouth bass) EHQs were virtually the same for all alternative groups, except for Alternative Groups A and B, which were approximately one-third to three-quarters of an order of magnitude, respectively, higher than the other alternative groups (Figures I.14 and I.15). Consequently, except for Alternative Groups A and B, risk of uranium chemical toxicity to fish receptors does not appear to be an important discriminator among the other alternative groups.

All other aquatic animal receptors had EHQs that were less than those of carp, largescale/mountain sucker, and smallmouth bass. Therefore, only a negligible risk of uranium chemical toxicity to these receptors exists under all the alternative groups.

I.4 Consultations

DOE consults with the National Marine Fisheries Service and the U.S. Fish and Wildlife Service regarding potential actions that may affect sensitive habitats or species on the Hanford Site. Copies of the DOE consultation letters and agency responses are included in Attachment B to this appendix.

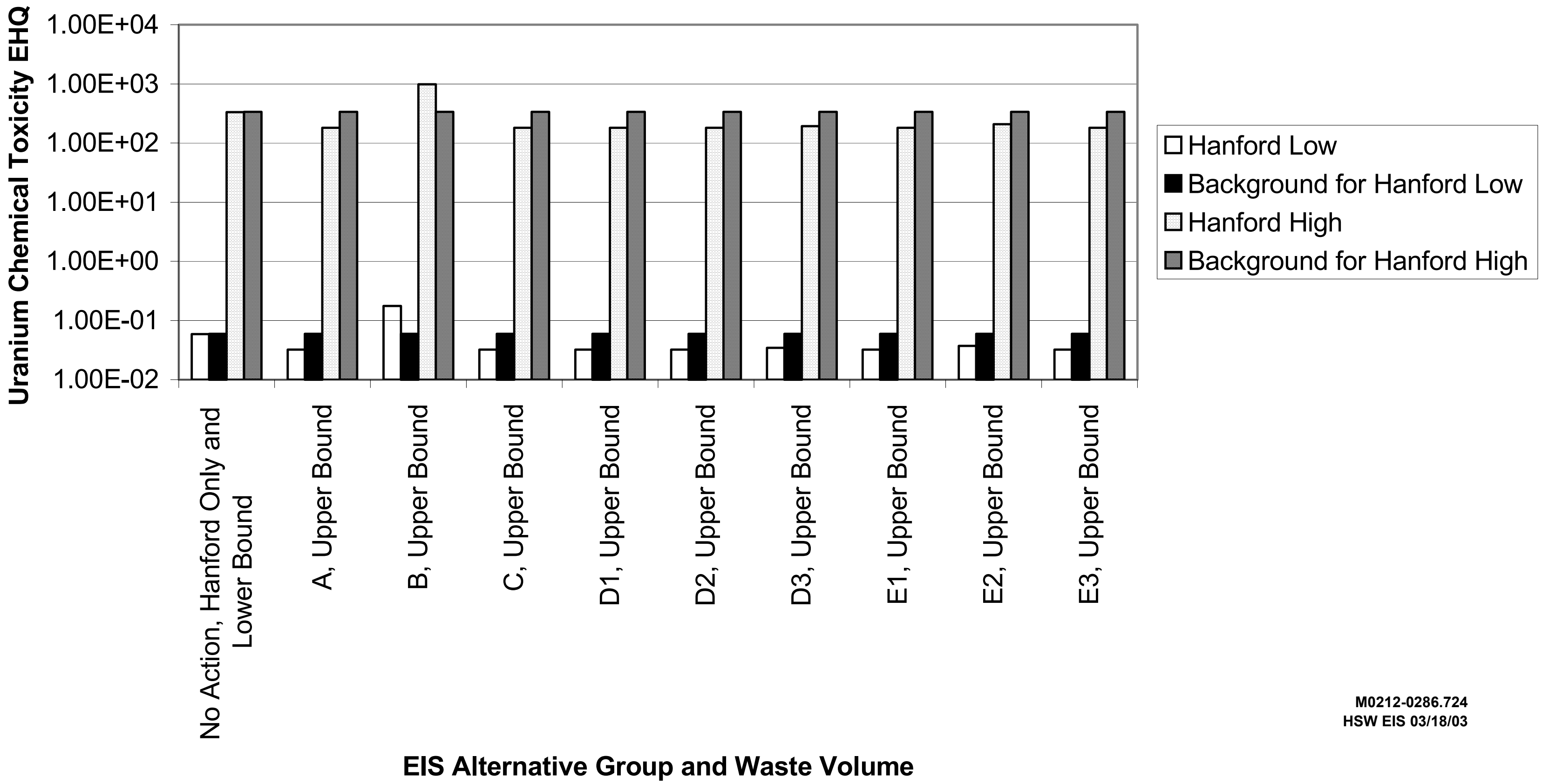

Figure I.12. Woodhouse's Toad Tadpole Low and High Uranium Chemical Toxicity EHQs for Each Alternative Group in the 2500- to 10,000-Year Time Period for Background and the Hanford Scenario

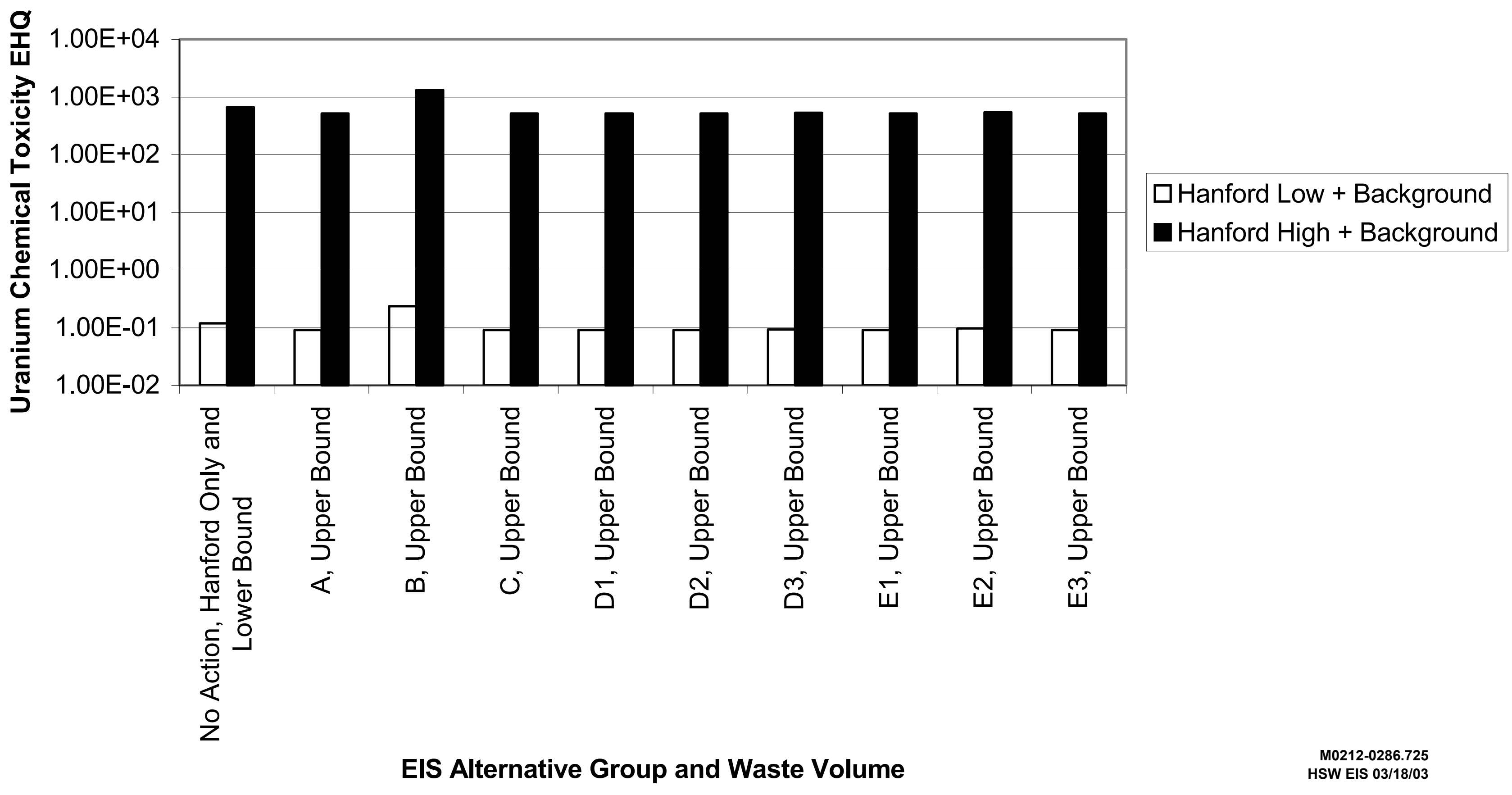

Figure I.13. Woodhouse's Toad Tadpole Low and High Uranium Chemical Toxicity EHQs for Each Alternative Group in the 2500- to 10,000-Year Time Period for the Hanford Plus Background Scenario

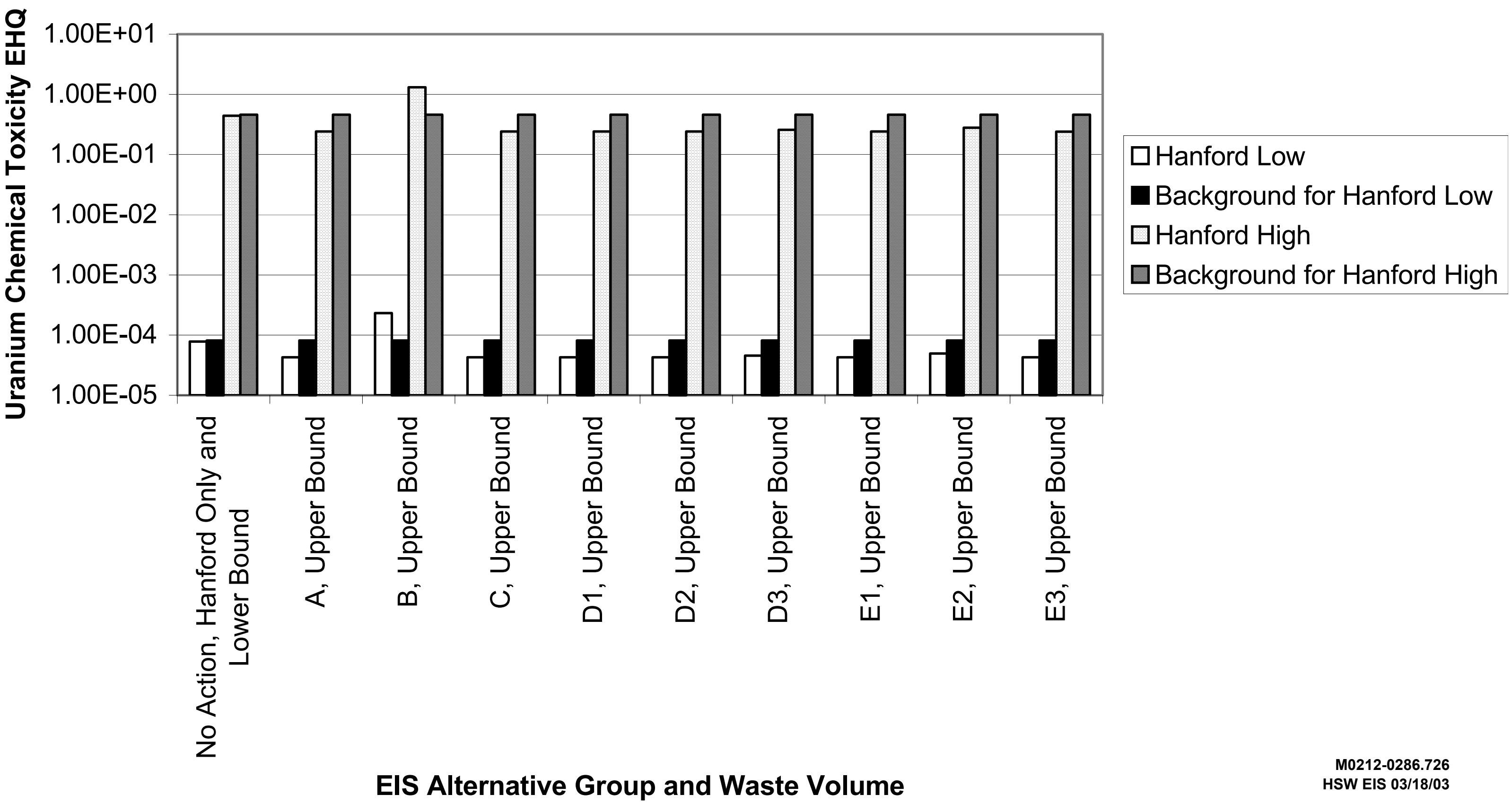

Figure I.14. Carp Low and High Uranium Chemical Toxicity EHQs for Each Alternative Group in the 2500- to 10,000-Year Time Period for Background and the Hanford Scenario

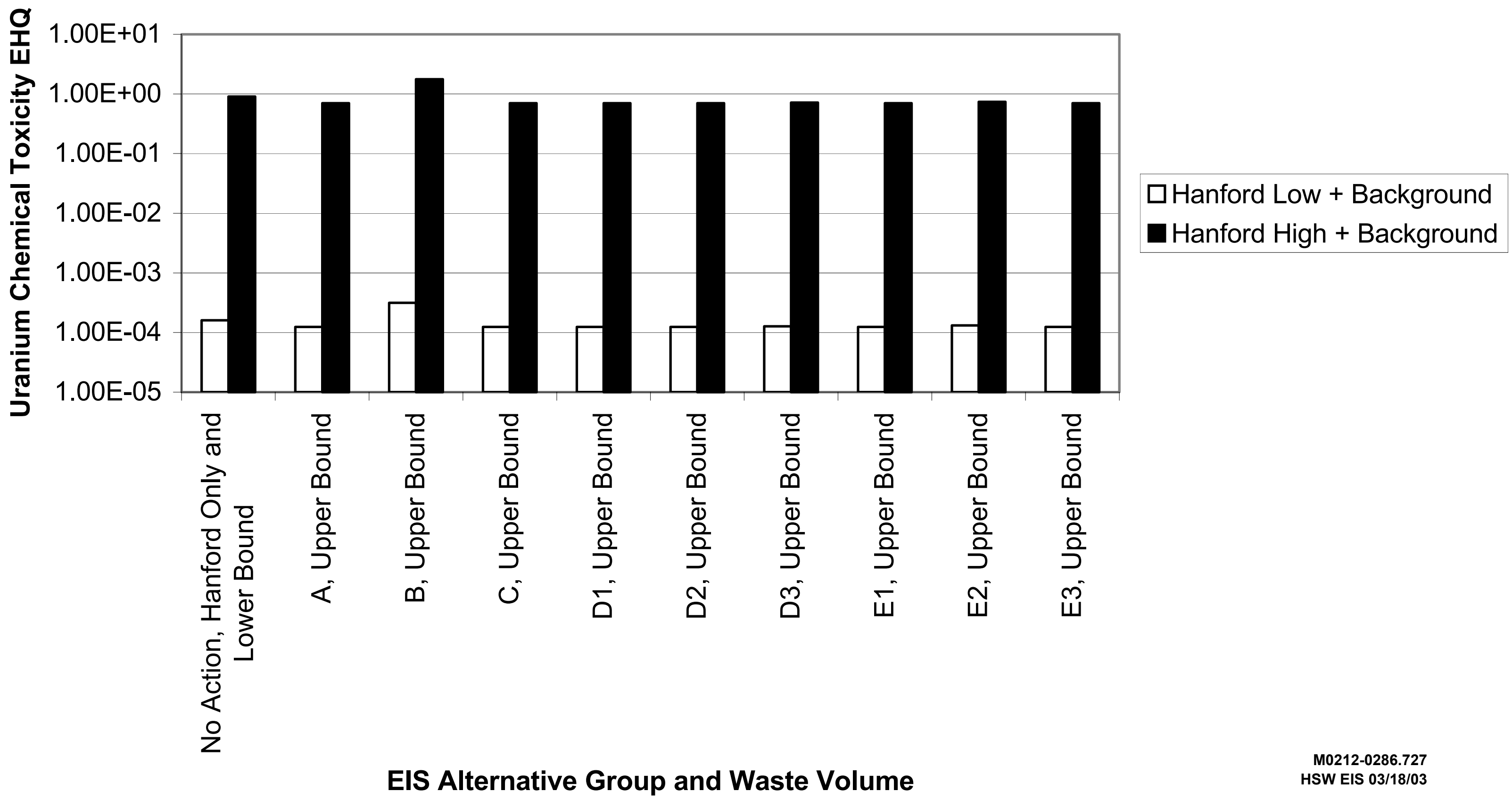

Figure I.15. Carp Low and High Uranium Chemical Toxicity EHQs for Each Alternative Group in the 2500- to 10,000-Year Time Period for the Hanford Plus Background Scenario

I.5 References

16 USC 703-712. *Migratory Bird Treaty Act.* Online at: http://www4.law.cornell.edu/

Baker, S. 2000. *Effects of Fire on Soil Seed Banks on the Hanford Site*. PNNL-13888, Pacific Northwest National Laboratory, Richland, Washington.

Becker, J. M., and M. R. Sackschewsky. 2001a. *Addendum to the 200 West Area Dust Mitigation Strategies: Treatment of the Dust Source Area*. Letter Report to CH2M Hill Hanford Group, PNNL-13884, Pacific Northwest National Laboratory, Richland, Washington.

Becker, J. M., and M. R. Sackschewsky. 2001b. *Partial Re-vegetation of the Dust and Blowing-Sand Source Area: A Proposal for Use of a 175K$ SEP Fine*. Letter Report to U.S. Department of Energy Office of River Protection, PNNL-13889, Pacific Northwest National Laboratory, Richland, Washington.

Belnap, J. 1993. "Recovery Rates of Cryptobiotic Crusts: Innoculant Use and Assessment Methods." *Great Basin Naturalist* 53(1):89-95.

Belnap, J. and K. T. Harper. 1995. "Influence of Cryptobiotic Crusts on Elemental Content of Tissue of Two Desert Seed Plants." *Arid Soil Research and Rehabilitation* 9:107-115.

Belnap, J., J. H. Kaltenecker, R. Rosentreter, J. Williams, S. Leonard, and D. Eldrige. 2001. *Biological Soil Crusts: Ecology and Management*. Technical Reference 1730-1732. Bureau of Land Management, Denver, Colorado.

BMNHC. 2000. Descriptions of habitat requirements of Washington's mammals. Burke Museum of Natural History and Culture, University of Washington, Seattle. Online at: http://www.washington.edu/burkemuseum/mammalogy/mamwash/mamwash.html.

Brandt, C. A. 1994. *Biological Review for the Environmental Restoration Disposal Facility (ERDF) Rail Line*. Letter Report to C. Hodge, Westinghouse Hanford Company, PNNL-14142, Pacific Northwest National Laboratory, Richland, Washington.

Brandt, C. A. 1998. *Blanket Biological Review for General Maintenance Activities within Active Burial Grounds, 200 E and 200 W Areas, ECR #98-200-031a*. Letter Report to B.M. Barnes, Waste Management Hanford, Inc., PNNL-14141, Pacific Northwest National Laboratory, Richland, Washington.

Brandt, C. A. 1999. *Blanket Biological Review for General Maintenance Activities within Active Burial Grounds, 200 E and 200 W Areas, ECR #99-200-042*. Letter Report to B.M. Barnes, Waste Management Hanford, Inc., PNNL-13878, Pacific Northwest National Laboratory, Richland, Washington.

Bryce, R. W., C. T. Kincaid, P. W. Eslinger, and L. F. Morasch (eds.). 2002. *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability*. PNNL-14027, Pacific Northwest National Laboratory, Richland, Washington.

CEQ. 1993. *Incorporating Biodiversity Considerations into Environmental Impact Analysis Under the National Environmental Policy Act*. Council on Environmental Quality, Executive Office of the President, Washington, D.C.

DOE. 1993. *Radiation Protection of the Public and the Environment*. DOE Order 5400.5, U.S. Department of Energy, Washington, D.C.

DOE. 2002. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.* DOE-STD-1153-2002, Office of Environmental Policy and Guidance Air, Water, and Radiation Division and the Biota Dose Assessment Committee, U.S. Department of Energy, Washington D.C. Online at: http://tis.eh.doe.gov/techstds/tsdrafts/envr0011.

DOE-RL. 1995a. *Ecological Compliance Assessment Management Plan*. DOE/RL-95-11, Rev. 1., U.S. Department of Energy, Richland, Washington.

DOE-RL. 1995b. *Hanford Site Risk Assessment Methodology*. DOE/RL-91-45, Rev. 3, Richland, Washington.

DOE-RL. 1995c. *Mitigation Action Plan for the Environmental Restoration Disposal Facility*. DOE/RL-95-24, Rev. 1, U.S. Department of Energy, Richland, Washington.

DOE-RL. 1998. *Screening Assessment and Requirements for a Comprehensive Assessment: Columbia River Comprehensive Impact Assessment*. DOE/RL-96-16, Rev. 1, U.S. Department of Energy, Richland, Washington.

DOE-RL. 2000. *Type B Accident Investigation -- U.S. Department of Energy Response to the 24 Command Wildland Fire on the Hanford Site -- June 27-July 1, 2000.* DOE/RL-2000-63, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Online at: http://www.hanford.gov/docs/rl-2000-63/index.html.

DOE-RL. 2001. *Hanford Site Biological Resources Management Plan*. DOE/RL-96-32, Rev. 0., U.S. Department of Energy, Richland, Washington.

DOE-RL. 2003. *Hanford Site Biological Resources Mitigation Strategy*. DOE/RL-96-87, Rev. 0., U.S. Department of Energy, Richland, Washington. Online at: http://www.pnl.gov/ecology/ecosystem/Docs/BRMiS.pdf.

Domingo, J. L. 2001. "Reproductive and Developmental Toxicity of Natural and Depleted Uranium: a Review." *Reproductive Toxicology* 15:603-609.

Dourson, M. L. and J. F. Stara. 1983. "Regulatory History and Experimental Support of Uncertainty (Safety) Factors." *Regulatory Toxicology and Pharmacology* 3:224-238.

EPA. 1992. *Framework for Ecological Risk Assessment*. EPA/630/R-92/001, U.S. Environmental Protection Agency, Washington D.C.

EPA. 1998. *Guidelines for Ecological Risk Assessment*. EPA/630/R-95/002F, U.S. Environmental Protection Agency, Washington D.C. Online at: http://cfpub.epa.gov/ncea/cfm/ecorsk.cfm?ActType=default.

Eslinger, P. W., C. Arimescu, B. A. Kanyid, and T. B. Miley. 2002. *User Instructions for the Systems Assessment Capability, Rev. 0, Computer Codes. Volume 2: Impact Modules*. PNNL-13932-Volume 2, Pacific Northwest National Laboratory, Richland, Washington.

Fellows, R. J., C. C. Ainsworth, C. J. Driver, and D. A. Cataldo. 1998. "Dynamics and Transformations of Radionuclides in Soils and Ecosystem Health." In *Soil Chemistry and Ecosystem Health*, ed. P. M. Huang, pp. 85-132. Soil Science Society of America, Madison, Wisconsin.

Johansen, J. R., J. Ashley, and W. R. Rayburn. 1993. "Effects of Rangefire on Soil Algal Crusts in Semiarid Shrub-Steppe of the Lower Columbia Basin and Their Subsequent Recovery." *Great Basin Naturalist* 53(1):73-88.

Kincaid, C. T., P. W. Eslinger, W. E. Nichols, A. L. Bunn, R. W. Bryce, T. B. Miley, M. C. Richmond, S. F. Snyder, and R. L. Aaberg. 2000. *System Assessment Capability (Rev. 0) Assessment Description, Requirements, Software Design, and Test Plan*. BHI-01365, Draft A., Bechtel Hanford, Inc., Richland, Washington. Online at: http://www.bhi-erc.com/projects/vadose/sac/sacdocs.htm.

Labrot, F., J. F. Narbonne, P. Ville, M. Saint Denis, and D. Ribera. 1999. "Acute Toxicity, Toxicokinetics, and Tissue Target of Lead and Uranium in the Clam Corbicula fluminea and the Worm Eisenia fetida: Comparison with the Fish Brachydanio rerio." *Archives of Environmental Contamination and Toxicology* 36:167-178.

Link, S. O., B. D. Ryan, J. L. Downs, L. L. Cadwell, J. A. Soll, M. A. Hawke, and J. Ponzetti. 2000. "Lichens and Mosses on Shrub-steppe Soils in Southeastern Washington." *Northwest Science* 74(1):50-56.

Opresko, D. M., B. E. Sample, and G. W Suter II. 1995. *Toxicological Benchmarks for Wildlife: 1995 Revision*. ES/ER/TM-86/R2, Lockheed Martin Energy Systems, Inc., Oak Ridge, Tennessee. Online at: http://www.osti.gov.

Renne, D. S. and D. A. Wolf. 1976. *Experimental Studies of Herbicide Drift Characteristics*. BNWL-SA-5848, Pacific Northwest Laboratory, Richland, Washington.

Sackschewsky, M. R. 2000. *Blanket Biological Review for General Maintenance Activities within Active Burial Grounds, 200 E and 200 W Areas, ECR #2000-200-013*. Letter Report to B.M. Barnes, Waste Management Hanford, Inc., PNNL-13886, Pacific Northwest National Laboratory, Richland, Washington.

Sackschewsky, M. R. 2001. *Blanket Biological Review for General Maintenance Activities within Active Burial Grounds, 200 E and 200 W Areas, ECR #2001-200-048*. Letter Report to B.M. Barnes, Fluor Daniel Hanford, Inc., PNNL-13887, Pacific Northwest National Laboratory, Richland, Washington.

Sackschewsky, M. R. 2002a. *Blanket Biological Review for General Maintenance Activities within Active Burial Grounds, 200 East and 200 West Areas, ECR #2002-200-034*. Letter Report to B. M. Barnes, Fluor Daniel Hanford, Inc., PNNL-14133, Pacific Northwest National Laboratory, Richland, Washington.

Sackschewsky, M. R. 2002b. *Ecological Compliance Review for the Vegetation Removal on 218-W-6, 200 West Area, ECR #2002-200-031*. Letter Report to D.E. Faulk, Fluor Hanford, PNNL-14132, Pacific Northwest National Laboratory, Richland, Washington.

Sackschewsky, M. *ECR #2002-600-012*. Letter Report to K.M. McDonald, Fluor Hanford, PNNL-13882, Pacific Northwest National Laboratory, Richland, Washington.

Sackschewsky, M. R. 2002d. *Ecological Compliance Review for the Hanford Solid Waste EIS – Borrow Area C (600 Area), Stockpile and Conveyance Road area (600 Area), Environmental Restoration Disposal Facility (ERDF) (600 Area), Central Waste Complex (CWC) Expansion (200 West Area), 218-W-5 Expansion Area (200 West Area), New Waste Processing Facility (200 West Area), Undeveloped Portion of 218-W-4C (200 West Area), western half and northeastern corner of 218-W-6 (200 West Area), Disposal Facility near Plutonium-Uranium Extraction (PUREX) Facility (200 East Area), ECR #2002-600-012b*. Letter Report to K.M. McDonald, Fluor Hanford, PNNL-14233, Pacific Northwest National Laboratory, Richland, Washington.

Sackschewsky, M. R. and J. M. Becker. 2001. *200 West Area Dust Mitigation Strategies*. Letter Report to CH2M Hill Hanford Group, PNNL-13883, Pacific Northwest National Laboratory, Richland, Washington.

Sackschewsky, M. R. and J. L. Downs. 2001. *Vascular Plants of the Hanford Site*. PNNL-13688, Pacific Northwest National Laboratory, Richland, Washington.

Shields, L. M., C. Mitchell, and F. Drouet. 1957. "Alga- and Lichen-Stabilized Surface Crusts as Soil Nitrogen Sources." *American Journal of Botany* 44:489-498.

Soll, J. A., and C. Soper (eds). 1996. *Biodiversity Inventory and Analysis of the Hanford Site, 1995 Annual Report*. The Nature Conservancy of Washington, Seattle, Washington.

Suter. G. W. 1993. *Ecological Risk Assessment*. Lewis Publishers, Chelsea, Michigan.

Tiller, B. L., R. K. Zufelt, L. L. Cadwell, L. Bender, S. Turner, and G. K. Turner. 2000. *Population Characteristics and Seasonal Movement Patterns of the Rattlesnake Hills Elk Herd - Status Report*. PNNL-13331, Pacific Northwest National Laboratory, Richland, Washington.

TNC. 1999. *Biodiversity Inventory and Analysis of the Hanford Site: Final Report 1994-1999*. The Nature Conservancy of Washington, Seattle, Washington.

WDFW. 2002. Animal species of concern lists and status definitions. Washington Department of Fish and Wildlife, Olympia, Washington. Online at: http://www.wa.gov/wdfw/wlm/diversty/soc/concern.htm.

WHC. 1995. *Guidelines for Coordinated Management of Noxious Weeds at the Hanford Site*. WHC-SD-EN-AP-187, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

WNHP. 2002. Rare plant lists and status definitions. Washington State Natural Heritage Program, Olympia, Washington. Online at: http://www.wa.gov/dnr/htdocs/fr/nhp/refdesk/fsrefix.htm.